In this Issue: Power From the Sun's Heat.—The Spring Meeting of the American Society of Mechanical Engineers.—Failure of the Peoria Reinforced Concrete Bridge.—Engineering Literature Supplement.

ENGINEERING NEWS

Volume 61. No. 19.

220 Broadway, NEW YORK, THURSDAY, MAY 13, 1909.

$5.00 per Year. Single Copies, 15 Cents.

FOR REINFORCING CONCRETE
use
"Hudson" Steel Bar
TWISTED AND PLAIN
Sizes, ¼ in. to 1¼ in.
High Elastic Limit
HUDSON STRUCTURAL STEEL CO.
136th Street and Southern Boulevard
New York
All sizes in stock. Immediate shipment guaranteed

RINALD BROS.
1142-1146 N. Hancock St., Philadelphia
Sole Manufacturers of
"BESSEMER PAINT"

ALMA
PORTLAND CEMENT
STANDARD BRAND OF MIDDLE WEST
Specially Adapted to All Reinforced Concrete and High-Class Work
ALMA CEMENT COMPANY
Wellston, Ohio

DR. CHAS. F. McKENNA
Consulting Chemist and Chemical Engineer
Expert in Technology and
TESTING OF MATERIALS
Bureau of Inspection
FULTON BUILDING, HUDSON TERMINAL, 50 CHURCH STREET, NEW YORK CITY

CHICAGO
CONCRETE
MIXER
Chicago Concrete Machinery Co.
Chicago

LOOMIS FILTERS
Improved System — Established 1880 — Results Guaranteed
LOOMIS-MANNING FILTER CO.
Main Office, 828 Land Title Bldg., Philadelphia, Pa.
New York, Boston, Buffalo, Baltimore, Washington, Chicago

LATROBE FLANGES
Soft Steel Weldless Flanges
Forged and Rolled from
SOLID STEEL INGOTS
Suitable for High-Pressure Steam, Water or Gas Lines
For Details as to Prices, etc., address
RAILWAY STEEL-SPRING COMPANY
General Offices
Cortlandt Bldg., 30 Church St., New York

HYDREX
THE TOUGHEST, STRONGEST, MOST ELASTIC WATERPROOFING FELT
"THE MEMBRANE METHOD"
HYDREX FELT AND ENGINEERING CO., Engineers and Experts in Waterproofing Problems
120 Liberty Street, New York — Chicago — Washington

Sewer Pipe, Flue Linings, Etc., Etc.
3 TO 36 INCH
ST. MARYS SEWER PIPE CO.
ST. MARYS ELK CO., PA.

FOR ALL CITY SEWERS
GLAZED CLAY SEWER PIPE
Better and cheaper than brick or other material. Demand constantly increasing. We have it in 27, 30 and 36-inch, and all smaller sizes. In business fifty years. Write the manufacturer.
EVENS & HOWARD FIRE BRICK COMPANY, St. Louis, Mo.

An Acceptable Substitute
For BRICK SEWERS
Large Sizes VITRIFIED PIPE
No Skilled Labor Required
BLACKMER & POST PIPE CO., ST. LOUIS
Pamphlet, "Vitrified Pipe vs. Brick Sewers"

Vitrified Pipe—Double Strength Extra Heavy Culvert Pipe
All Sizes
MANUFACTURED FROM SHALE
W. S. DICKEY CLAY MFG. CO
Kansas City, Mo.

MACOMB SEWER PIPE CO. — MACOMB, ILL.
Superior Vitrified Sewer Pipe — Double Strength Extra Thick Culvert Pipe

ALL SIZES MONMOUTH SEWER PIPE MADE BY
MONMOUTH MINING & MFG. CO., Monmouth, Ill.

NATIONAL PAINT WORKS — Established 1876
TECHNICAL PAINTS FOR METAL
Main Sales Office: 100 William Street, New York — Works: Williamsport, Pa.
Branches: Chicago, San Francisco, Philadelphia, Washington, D. C.

SMITH MIXER
SYMONS CRUSHERS
See our advertisement on page 67

CRANES OF ALL TYPES AIR HOISTS
WHITING CUPOLAS, LADLES, TUMBLERS, TRUCKS, TURNTABLES, etc.
Send for Catalogs — COMPLETE EQUIPMENTS — Correspondence Solicited
Gray Iron, Malleable, Steel, Brass, Car Wheel and Pipe Foundries
WHITING FOUNDRY EQUIPMENT COMPANY, - HARVEY, ILL.

The wonderful carrying power of belt conveyors is becoming generally understood and appreciated; but many prospective buyers and a few present users are doubtful about the real economy of such conveyors as measured by dollar tonnage that includes both running and renewal costs. Either a cheap belt or a high priced one may prove uneconomical in service, if the tonnage moved per dollar of first cost plus the total running expense is too small. Measured by closely recorded dollar tonnages, the TEXTOL service given by the Textol conveyor belting, made by the National Belting Co. of Lawrence, Mass., proves it to be the most economical of all, combining with low first cost special features of construction that make for heavy tonnage and long wear in hard service. It is finished especially to suit the particular class of work for which designed, and its service proves the most convincing of arguments to all who have heretofore doubted the efficiency of belt conveyors in general. Write them, telling your conditions and let them show you how to diminish your tonnage costs.

THE COMING POWER
Kerosene and Crude Oil
ENGINES
THE B. M. OSBUN CO.
Chicago

ROTARY KILN LININGS
Highest grade flint clay. Natural high alumina contents. Hand made; repressed; uniform in size and quality and true to shape. The only *really satisfactory* Kiln Linings. Used from Ocean to Ocean and from Canada to Mexico.
HARBISON-WALKER REFRACTORIES CO.
PITTSBURG, PA.

PROPOSALS
See pages immediately following last reading

"Lehigh" Portland
CEMENT
High Tensile Strength — Finely Ground
Light and Uniform in Color
Recommended for High-Class Engineering Work
Manufactured by
LEHIGH PORTLAND CEMENT CO.
ALLENTOWN, PA.
WESTERN OFFICE
725 Rockefeller Building — CLEVELAND, OHIO

Will Furnish and Erect in United States and Foreign Countries
Wooden Stave Pipe
EXCELSIOR WOODEN PIPE CO.
SAN FRANCISCO
Advertisement is on page 14.

THE PULSOMETER STEAM PUMP
See our advertisement on page 5

PIPE DIP
Brick Filler—Roofing—Paints
AMERICAN ASPHALTUM AND RUBBER CO.
600-609 Harvester Building, Chicago

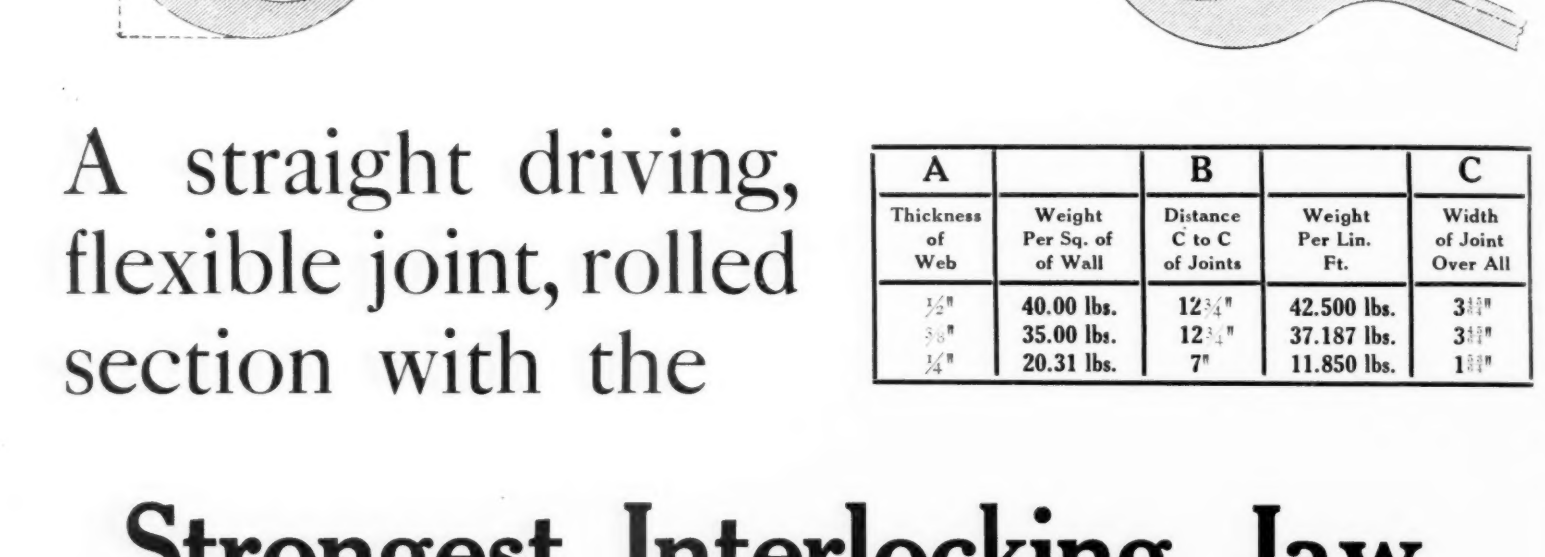
The Paint of standard quality for permanent protection of steel iron and wood.
FEROX
(TRADE MARK)
HAMMOND, BOYNTON PAINT AND CHEMICAL CO.
Main Office and Factory, Norwich, Conn. — Boston, New York and Philadelphia

MAKE TIGHT STEAM JOINTS BY USING CORRUGATED COPPER GASKETS FOR FLANGED PIPES CYLINDERS, CHESTS, Etc.
Samples and Circulars free
UNITED STATES MINERAL WOOL CO., 140 CEDAR STREET, NEW YORK CITY

Buyers' Reference, Page 35

Alphabetical Index of Advertisers, Page 39.

Lackawanna Steel Sheet Piling



A straight driving, flexible joint, rolled section with the

A		B		C
Thickness of Web	Weight Per Sq. of of Wall	Distance C to C of Joints	Weight Per Lin. Ft.	Width of Joint Over All
½"	40.00 lbs.	12¾"	42.500 lbs.	3$\frac{13}{16}$"
⅜"	35.00 lbs.	12¾"	37.187 lbs.	3$\frac{13}{16}$"
¼"	20.31 lbs.	7"	11.850 lbs.	1$\frac{13}{16}$"

Strongest Interlocking Jaw

on the market. Three points of contact to make it practically watertight. Nothing to shear off in handling, shipping or driving.

Lackawanna Steel Company

APPLY TO

General Sales Office: 2 Rector Street, New York

OR THE NEAREST SALES OFFICE

CHICAGO **DETROIT** **CLEVELAND** **BOSTON** **CINCINNATI**
ATLANTA **PITTSBURG** **PHILADELPHIA** **BUFFALO** **SAN FRANCISCO**

ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 61. No. 19. 220 Broadway, New York, May 13, 1909.

TABLE OF CONTENTS.

LEADING ARTICLES:	Page.
Power from the Sun's Heat (illustrated)	509
Experiments in the Development of Power from the Sun's Heat (illustrated); H. E. Willsie	511
Failure of a Portion of a Steel Tower Electric Transmission Line in California (illustrated); Edwin Duryea, Jr., M. Am. Soc. C. E.	515
Calorific Value of California Fuel Oil; R. W. Fenn, M. Am. Soc. C. E.	516
Hydraulic Gate Valve for the Chicago Water-Works (illustrated)	518
The Use of Asphaltic Flux for Coating Macadam Roads at Palo Alto, Cal.; J. F. Byxbee, Jr.	518
A Machine for Tracing the Profiles of Rail Sections (illustrated)	519
Block Signal Statistics for Railways of the United States	520
A Unique Belt Conveyor (illustrated); E. C. Soper, Jun. Am. Soc. M. E.	525
A New Transmission Dynamometer (illustrated); Wm. H. Kenerson, M. Am. Soc. M. E.	526
Spring Meeting of the American Society of Mechanical Engineers, at Washington, D. C.	527
The Collapse of the Reinforced-Concrete Arch Bridge Across the Illinois River at Peoria, Ill. (illustrated)	529

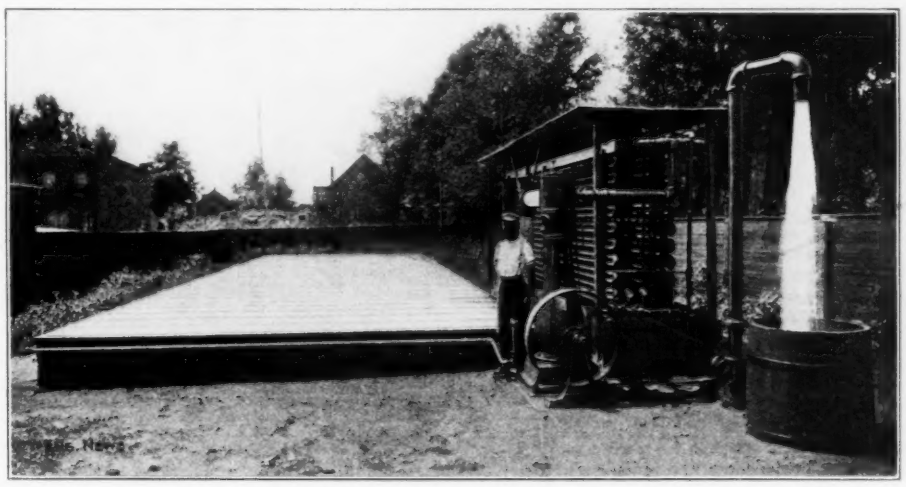
	Page.
EDITORIAL	521
A Request for Brown Prints—Enlargement of the Work of the North Carolina State Board of Health—Another Project to Turn the City Water-Works of Philadelphia Over to Private Control and Profit—The Failure of the Foundations of the Peoria Bridge—Public Streets as Playgrounds in New York City.	
The Utilization of Low-Temperature Heat to Produce Power	522
LETTERS TO THE EDITOR	522
Reinforced Concrete for Boiler-House Floors: W. A. Hoyt—Further History of the Combination Retaining Wall and Quay at Chatenay, France (illustrated); Alexis Saurbrey—Standard Methods for the Bacterial Examination of Water; Philip Burgess—Cost of Operating Stone-Crushing Plants; C. G. Smith, Jr.; L. Bush—Should Steel for Concrete Reinforcement Be Painted? Frank Cheesman.	
ENGINEERING NEWS OF THE WEEK	532
PERSONALS	534
ENGINEERING SOCIETIES	534
ENGINEERING LITERATURE SUPPLEMENT	57

Power From the Sun's Heat.

It is nothing new to get power from the sun's heat. Nature has been doing it for untold ages. What have been called the great sources of power in Nature—waterfalls, winds, waves and even the energy stored up in coal and other fuels—can one and all be traced back eventually to the heat of the sun.

Nor is it new to use the heat of the sun directly as a source of power. The Swedish inventor Ericsson built a sun motor consisting of a series of mirrors so placed about a center as to reflect the heat of the sun toward a central focus where a small steam boiler was located.

The inherent limitations of this class of sun motor are obvious. Only very small powers can be obtained in this way. The "inverted umbrella" which the reflector resembles is a costly and cumbrous affair, not adapted to endure wind and weather. The heating surface of the boiler is limited to the external surface of a small cylinder only. In short, for these and other reasons, the Ericsson or "reflector" type of sun motor is merely a scientific toy, of possible value as a foundation for a stock-selling enterprise, but barren of any commercial usefulness.



A STEAM ENGINE OPERATED BY THE SUN'S HEAT AT FACTORY, PHILADELPHIA, AUGUST, 1907.
Frank Shuman, Inventor.

Some three years ago the sun motor problem was attacked by Mr. Frank Shuman, of Tacony, Philadelphia. Mr. Shuman is an engineer and inventor of large practical experience who had already made some noteworthy and valuable inventions, and was equipped with means to undertake larger tasks. Aware of the inherent difficulties which prevented the sun motor of Ericsson from practical success, he recognized that any apparatus to utilize the sun's heat must be stationary and not movable. Again Ericsson sought to attain high temperatures by concentrating the sun's rays to a focus. Mr. Shuman adopted the entirely different plan of accumulating the heat or, so to speak, bottling it up.

To state the case scientifically, the sun is pouring a steady stream of radiant heat down upon every square yard of the earth's surface. Under ordinary conditions this is given out as fast as it is received by radiation and conduction to the surrounding atmosphere. Check this radiation and conduction by an outer covering of glass, as in a greenhouse, and the temperature within rapidly rises, until the rate of loss from the outer surface of the glass equals the rate at which heat is received from the sun.

Mr. Shuman began with experiments to see how hot such an enclosed space would become and also he quantitatively measured the amount of heat per unit of area—say per square foot—delivered by the sun on a clear summer day in the latitude of Philadelphia. He constructed first some experimental "hot boxes"—simply flat wooden boxes or frames covered with a double layer of glass with an air space between and containing water in the bottom. He found that the inside of such a box soon attained a temperature above the boiling point of water. The first engine which Mr. Shuman ran by sun power was a tiny toy engine such as are sold for a dollar. The steam was furnished by one of these small experimental hot boxes in which coils of small piping were placed. These pipes were heated by the rays of the sun until the water in them boiled and generated steam sufficient to drive the engine. Then the experiment was repeated with another engine of considerably larger size, taking the steam from a proportionally larger hot box.

After the success of this second experiment Mr. Shuman constructed on the grounds adjoining his residence in Tacony a sun engine of commercial size.

The accompanying illustration (Fig. 1) shows this plant. It will be seen that the "hot box" covered a very considerable area, about 20 × 60 ft. Inside this box were placed iron pipes well blackened so as to absorb radiant heat efficiently. These pipes constituted the "boiler" of the plant. Ether was injected into them and was evaporated into steam, which was used in a vertical steam engine with a 9 × 10-in. cylinder. The exhaust from this engine was piped to the condenser seen on the left, consisting of coils of pipe over which cool water from a well was sprayed.

A great deal of ingenuity was expended in working out the details of this plant, and it achieved practical success to the extent that it worked steadily on sunny days during the summer of 1907 and 1908, pumping thousands of barrels of water and demonstrating the practical possibility of getting power from sun heat by the "hot-bed" plan.

It also demonstrated, however, that radically different methods must be adopted to place sun power on a commercial basis. Right at the outset it was seen that the extent of heating surface required to develop a horsepower in a plant built on these lines was so great that the first cost would be prohibitive. The pipe in the hot-bed corresponds exactly to the pipes in a water-tube boiler of an ordinary steam power plant, but whereas these latter are exposed to a fierce heat of 1,000° to 2,000° F., the pipes in the hot-bed are in a temperature of only 200° to 240° as a maximum. Hence instead of developing a horsepower with only one or two square feet of heating surface, as in a locomotive boiler, or eight or ten square feet, as in a stationary boiler, a sun engine, built on this plan, would require probably one or two hundred square feet.

So Mr. Shuman's first sun motor, although it did a fair amount of mechanical work, was, like Ericsson's, a scientific toy and not a commercial success.

But like many another scientific toy, experience with it taught some useful lessons. For example, it showed very conclusively that until some revolutionary advance is made in the means of storing energy, no sun motor can be a commercial success in any humid climate where the sky is frequently covered with clouds. It is not at all uncommon in most parts of the globe to have not only whole days without sunshine but a succession of such days, or sometimes even weeks. Of course a power plant sub-

ject to such interruptions of operation would be wholly out of the question. No gains in economy could offset such irregularity of output.

Again, even when the sun shines all day and every day, the amount of heat given out varies greatly at different hours of the day. For example, at 9 a. m. the rate of heat absorption is only one-fifth that at noon, and by 4 p. m. the rate is no greater than at 9 a. m. Thus the Philadelphia plant shown in Fig. 1, which, of course, cooled off over night, would not get heated up so that the engine would start till about 11 a. m., and it knocked off work as early in the afternoon as if it belonged to the Sun union.

Evidently if sun power were to be put to practical use, some feasible method for storing energy was essential.

It became clear also that any construction for absorbing sun heat must be of very low cost and very durable. As already seen, we must collect the heat from a considerable area in order to develop much power. For example, the constant adopted by Mr. Shuman as the result of his experience is 160 sq. ft. per horsepower. Thus for a power plant of 1,000 HP. capacity a heat absorbing area of 160,000 sq. ft., or nearly four acres, would have to be provided. Manifestly any construction spread over so large a space must be simplicity itself or the cost of installation and maintenance will make sun power too expensive for consideration.

Fig. 2 illustrates in diagrammatic form the apparatus by which it is expected to place sun power on a commercial basis. Imagine the plant located on the arid plains of Arizona or of Egypt. A space 400 ft. square is graded to an absolute level and rolled hard and firm and is then rendered waterproof by covering it with asphaltum and at the same time given maximum power for absorbing solar radiation, its surface being black. Low walls on the four sides convert it into a shallow tank and long partitions divide the tank into 20 separate compartments, each 20 ft. wide and 400 ft. long. Between each one of these divisions is a narrow space which serves as a walk and also as a gutter to carry off water in case of rain, and also in case of the washing off of the glass with a hose.

This whole area is covered with glass; and great study has been given to the detail problems of framing to support this glass. Fig. 3 illustrates a section of the heat absorber in detail. It will be seen that the absorbing area is covered with a glazing of 16 × 24-in. window glass, and instead of using a double thickness with an air space between, as in the experimental plant at Philadelphia, the lower glass is dispensed with and reliance is placed instead on a thin layer of paraffin on top of the water, which is, of course, kept melted and transparent by the sun's heat. Experiments have shown that the paraffin is almost as efficient as the second layer of glass, and it removes the difficulty in keeping clean the inner surfaces of the double glass.

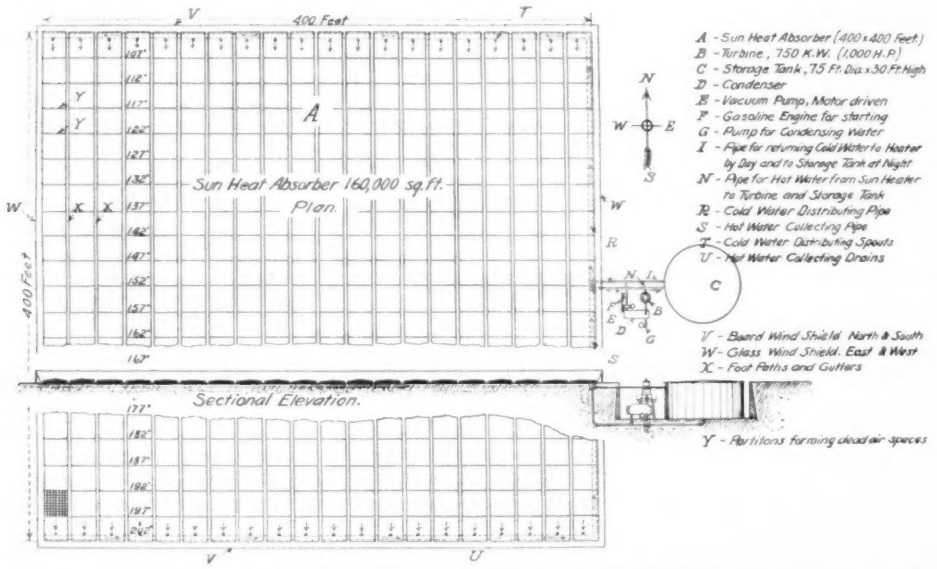

400 Feet
Sun Heat Absorber 160,000 sq. ft.
Plan.
Sectional Elevation.
A - Sun Heat Absorber (400 x 400 Feet)
B - Turbine, 750 K.W. (1,000 H.P.)
C - Storage Tank, 75 Ft. Dia. x 30 Ft. High
D - Condenser
E - Vacuum Pump, Motor driven
F - Gasoline Engine for starting
G - Pump for Condensing Water
I - Pipe for returning Cold Water to Heater by Day and to Storage Tank at Night
N - Pipe for Hot Water from Sun Heater to Turbine and Storage Tank
R - Cold Water Distributing Pipe
S - Hot Water Collecting Pipe
T - Cold Water Distributing Spouts
U - Hot Water Collecting Drains
V - Board Wind Shield. North & South
W - Glass Wind Shield. East & West
X - Foot Paths and Gutters
Y - Partitions forming dead air spaces

FIG. 2. GENERAL PLAN AND SECTIONAL ELEVATION OF PROPOSED SUN POWER PLANT OF 1,000 HP. CAPACITY.

Mr. Shuman describes the construction of the heat absorber further as follows:

The sides of each one of the divisions of the heat absorber are made of a 2 × 12-in. yellow pine plank. The bottom is an ordinary asphaltum pavement of slight depth, as it has no traffic upon it. This asphaltum bottom is very cheap, absolutely watertight, and clings against the yellow pine sides tightly. When expanded by the heat of the sun it exerts no pressure against the sides or ends, but becomes plastic, and merely rises very slightly in height. It is by nature black all through, and therefore will never require painting. It becomes semi-liquid under the sun's rays and flows automatically to a water level, and maintains this absolute level, even though there should be an actual settlement of the ground at either end. This asphaltum pavement, when put in on a proper sand or other rammed foundation, will be practically everlasting.

huge area is really a water heater, designed to receive cool water at one end and deliver hot water (after flowing a distance of 400 ft. exposed to the sun's rays) at the opposite end.

Mr. Shuman describes the proposed construction further as follows:

A special manner of making the glass covering air-tight and still allowing each sheet to expand and contract separately, is necessary. Glass set in putty would be too rigid; expansion and contraction would break it, and it would be extremely difficult to remove for possible repairs. By merely laying the glass on, too many cracks would be left open, which would tend to destroy the very desirable dead air space over the water. We use a very light cotton packing which goes under and joins the edges of the glass. This is compressed sufficiently by the weight of the glass and by the strips. After the glass has been set in this manner, the cotton at the butted joints is soaked with boiled linseed oil. This will oxidize rapidly and will make a practically air-tight joint. We can set glass in this manner more quickly, and more cheaply, than it can be done in any other way.

It will be noticed that the framework carrying the glass is constructed of creosoted wood. This, at first sight, may seem inadvisable. There are, however, cogent reasons for making this of wood. It is very difficult to prevent expansion and contraction of such an extended metallic framework under high temperatures. The metallic framework would have to project above the glass, and there would be a great increase in the amount of heat carried away by conduction, because the metallic framework extending into the hot air space under the glass would directly carry away a considerable quantity of heat. Wood does not possess this undesirable quality, and expands and contracts very little endwise. Under the conditions which obtain in the sun heat absorber (a steady damp atmosphere at high temperature) this creosoted wooden framework will probably last at least twenty years. At the end of that time it can be replaced, as it is comparatively inexpensive.

In order to better retain the heat absorbed in the water, we float upon it a thin film of paraffin. The stream of water passes through the heat absorber at a speed so slow that it flows quietly and almost imperceptibly along under the paraffin.

The sun heat absorber is protected from the wind at the north and south sides by a 10-ft. high board or corrugated iron fence, and on the east and west sides by a 10-ft. high fence set with glass after the manner of the sides of a hothouse. This fence, by preventing the sweep of the wind over the glass, tends to still further keep in the heat.

We have found by experiments that the larger the area of the sun heat absorber, the greater per square foot becomes its heat absorbing qualities. This is due to the fact that a small heat absorber radiates and loses heat from the sides and bottom very much more quickly; and

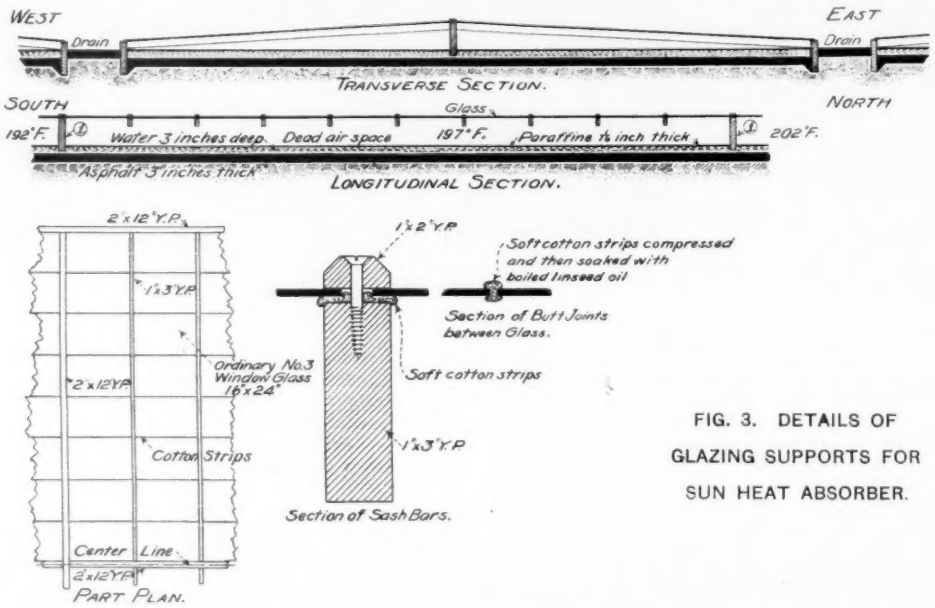


FIG. 3. DETAILS OF GLAZING SUPPORTS FOR SUN HEAT ABSORBER.

About six inches above the asphaltum bottom extends a glass covering like the flat roof of a hothouse. Crosswise, with the divisions running north and south, are partition strips running east and west which divide these divisions into 20 equal parts. These partition strips dip into the water (which runs 3 ins. deep on the asphaltum) about 2 ins., and go directly up against the glass; thus dividing the air above the water, in each one of the long divisions, into 20 equal parts. This has a remarkable effect in preventing radiation of heat.

As the reader has doubtless gathered, this that the air currents passing over a small heat absorber quickly carry the cool atmospheric air to all parts of the glass surface, and thus cause much more loss by conduction and convection. On a sun heat absorber as large as I have described, viz., 400 ft. square, the greater part of the surface is not actually touched by the cool atmospheric air, no matter from what direction the wind blows, unless it is too strong, the hot air lying above the glass has a tendency to cling, and the larger the surface the more difficult it is to sweep it off.

The simple and uniform construction of our sun heat

absorber enables us to construct the entire framework at our works, ship it to its destination, and there erect it almost without the stroke of a hammer.

It will be seen that the apparatus thus far described has for its sole object the heating of water by the rays of the sun. Mr. Shuman estimates that the sun heat absorber can be built complete for a cost of not more than 25 cts. per sq. ft. At this rate the 160,000 sq. ft. required for a 1,000-HP. plant would represent an investment of $40,000, or $40 per HP. Of course this may seem a high price for a boiler plant—for that is what this "sun heat absorber" actually is; but when we recall that this boiler plant does not require any fuel but collects its own and does its own stoking besides, the price seems low rather than high.

And now let us see how the flow of hot water from this apparatus can be utilized to generate power. Mr. Shuman's first plan was to use

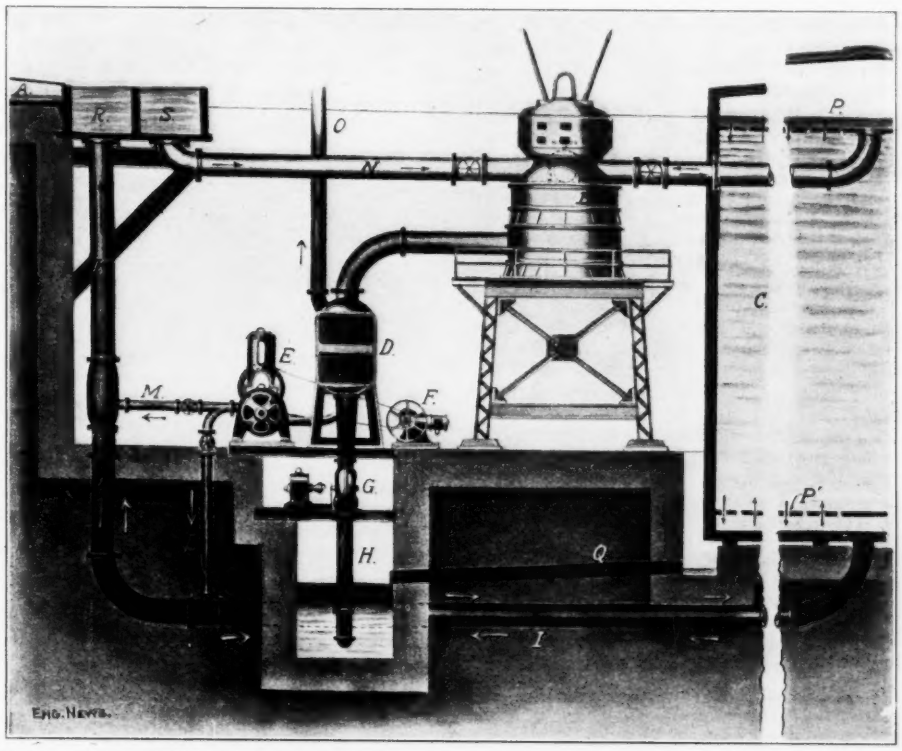


FIG. 4. ELEVATION OF STORAGE TANK AND POWER PLANT APPARATUS FOR DEVELOPING POWER FROM HOT WATER.

A—Sun Heater. (400 × 400 ft.)
B—Turbine, 750 KW. (1,000 HP.)
C—Storage Tank, 75 ft. dia., 30 ft. high.
D—Condenser.
E—Vacuum Pump, motor driven.
F—Gasoline Engine for starting.
G—Pump for condensing water.
H—Well for cold water.
I—Pipe for returning cold water to sun heater during day and to storage tank at night.
K—Pipe for returning cold water from storage tank and turbine to sun heater.
L—Pipe for returning cold water from turbine to bottom of storage tank at night.
M—Pipe for returning cold water from turbine to sun heater by day.
N—Pipe for hot water from sun heater to turbine and storage tank.
O—Overflow from condenser to be distributed for irrigation.
P,P'—Perforated Partitions for equalizing flow of water into and out of storage tank.
Q—Drain from tank pit to well.
R—Cold water sluice to sun heater.
S—Hot water sluice from sun heater.

some volatile liquid, such as ether or sulphur dioxide, as the working fluid, evaporating it by contact with the hot water in suitable apparatus and condensing it for use over again after passage through the engine.

There is, of course, nothing radical or unprecedented in such work. The sulphur dioxide engines designed by Prof. Josse, of Berlin, have been running for years in Germany, utilizing the heat in the exhaust steam of non-condensing engines.

However, after careful investigation by Mr. Shuman and the engineers associated with him, it was determined to use the hot water direct in a steam turbine, working below the atmospheric pressure, of course.

It is particularly important, however, to note the provision for heat storage. Referring to Fig. 2, it will be noted that the hot water is delivered from the heat absorber to a large storage tank 75 ft. in diameter and 30 ft. high. The sun heat absorber is expected to deliver hot water only about 6 hours out of the 24. During the remainder of that time the turbine will draw on the water stored in the tank. Fig. 4 illustrates the storage tank and turbine and the apparatus for circulating the hot and cold water. Mr. Shuman describes it as follows:

The hot water produced during the day is run into a properly insulated iron storage tank. Hot water is drawn from the top of the storage tank, and after passing through the turbine, where its heat is transformed into power, it is pumped back through the bottom of the tank, displacing the hot water towards the top and causing it to overflow into the turbine. It requires very little power to keep up this circulation, as it is almost entirely effected by gravity. To effect a proper upper displacement of the hot water by the cold water flowing in at the bottom, without mixing, the cold water must flow in, and the hot water flow out in such a manner as to make the circulation very slow and evenly divided throughout the entire area of the tank. This we do by running the cold water in through a pipe at the bottom of the tank under a perforated partition, the water distributing itself evenly under the partition, and flowing through the small holes into the tank above, thus causing a perfectly even displacement of the hot water towards the top. At the top of the hot water is a similar perforated partition about one foot below the water level. From over this partition the hot water flows into the turbine. This has been throughly tried and works perfectly.

There is practically no loss of heat in this iron storage tank. It is protected by insulation and set below the ground level to prevent air currents from striking it directly.

The main reason, however, why our storage tank is set below the ground level, is that in this manner we can obtain an almost natural circulation of the hot water from the sun heat absorber through the turbine, and from the sun heat absorber to the top of the storage tank; and after having passed through the turbine, back into the sun heat absorber; thus using up very little power to maintain the circulation, whereas, if the tank were set on top of the ground, this water would have to be lifted 28 ft. high, causing a loss of power in pumping the same.

We use our hot water directly in a low pressure turbine with specially designed nozzles and buckets.

With a vacuum of 28 ins. in the condenser and turbine, the boiling point of water is lowered to 102° F. Consequently, our hot water when it enters the turbine contains 100° more heat than it can hold. Therefore, as the hot water enters the nozzle of the turbine, nearly 10% explodes into steam, thus lowering the temperature of the remainder of the water to 102°. The water which has not been exploded into steam is projected forward by the expansion of the steam, and the steam and water strike the turbine buckets as a homogeneous mixture, having the velocity due to its expansion.

The amount of water driven forward by the steam reduces the velocity on leaving the nozzles much below what it would have been were there no water present; but the combined weight of the two is so much greater than the weight of pure steam, that the power exerted on the blades is the same as though no water were present. This reduction of velocity counterbalanced by increase of weight, is a great gain, as it enables the turbine to run at a much lower speed of revolution. In this manner we are able to secure the full thermal efficiency of a drop in temperature from 202° to 102° F.

The condensed water is pumped from the condenser in the usual manner, either back into the sun heat absorber for reheating immediately, or into the bottom of the storage tank for reheating the next day.

The amount of water required for condensing is the same as in steam practice under the same low pressure conditions.

In order to start a sun power plant, the vacuum in the condenser must first be formed. In large plants a small gasolene engine will do this. For small sun power plants a hand pump will do. As the sun power plant once in operation will run continuously, this is required for only 15 minutes or so on starting.

Our sun power plant will be run as follows: When the sun rises, the heat absorber is already filled to its proper level with the water used in the turbine the day before, which is at a temperature of about 100° F., due to loss by cooling off over night. Between sunrise and 9 o'clock this water is heated by the sun's rays, none of it being drawn off. Until 9 o'clock the turbine has been run by water from the storage tank. At 9 o'clock the storage tank is shut off, and the water from the south side of the sun heat absorber is circulated through the turbine at a rate of speed sufficient to liberate enough heat units to run it at the proper power. From the bottom of the condenser it flows again into the north end of the sun heat absorber. By 11 o'clock the water will have increasingly absorbed greater amounts of sun heat, and there will be a great deal more heat absorbed than the turbine can use. A gradually increasing portion of this hot water is run into the top of the storage tank and an equal amount of cold water run out of the bottom. The hot water which the sun heats between 11 and 3 o'clock is therefore used to run the turbine and also to fill the storage tank. About 3 o'clock, the storage tank being filled, the hot water from the sun heat absorber goes again direct to the turbine; flowing through that at a gradually increasing rate until about 5 or 6 o'clock. It is possible to run until about 6 o'clock with the water from the sun heat absorber, as there is a great deal of heat stored in it. This is gradually replaced by the cold water from the turbine. After 6 o'clock the water from the storage tank runs the turbine throughout the night hours, the same cycle to start again the next morning.

The Sun Power Co., which has been organized by Mr. Shuman to conduct experiments and place the invention on a commercial basis, proposes to erect a small unit, of say, 25 to 50-HP. at some point in southern Florida. It has been engaged for the past year in working out details of construction of its apparatus preparatory to this installation. After success has been attained with that engine, work will be undertaken on a plant of large size, located probably in Southern Arizona.

Experiments in the Development of Power from the Sun's Heat.

By H. E. WILLSIE.*

I have received a request from the Editor of Engineering News for a brief outline of the state of the art in the production of power from solar heat, and a statement of the experimental work which Mr. John Boyle, Jr., and I have done in our efforts to make sun power commercially possible. I will try to limit myself in the following to those schemes which have, according to my information, been put into material form. Some years ago Mr. Boyle and I agreed to avoid, as much as possible, publicity in connection with our experiments in this line. One reason for this is that building solar motors has not been an especially good recommendation for engineers. We began these experiments because the engineering problem of sun power development

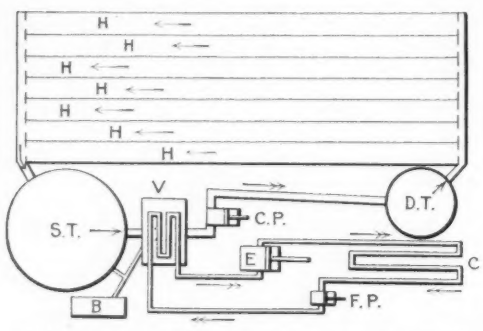
*Cranford, N. J.

has interested me since 1892 and because Mr. Boyle has properties in the Southwest that would be benefited by a successful sun power plant. As we have during the past six years made a large number of solar heat experiments, built four sun-power plants, and become convinced that there is, for some localities, a problem in the commercial utilization of solar heat worthy the attention of engineers, perhaps, a statement of what we have done should now be put on record and may prove interesting, especially as so much is being accomplished in other directions in the utilization of waste heat.

The Mirror Type.

When we began our experiments we found the state of the art mostly developed with the type of solar motor using reflectors to concentrate the sun's rays upon some sort of a boiler. The literature of the art usually begins by mentioning the report that Archimedes set fire to the Roman fleet at Syracuse by using mirrors to focus the sun's rays, but few valuable experiments are recorded until those of John Ericsson, of Monitor fame; although previous to Ericsson Mouchat had in operation in Paris a solar motor using mirrors to focus solar heat upon a steam boiler.

Church says, "The French Government condemned, after investigation, the solar engine of Mouchat because his silver-lined curved metallic reflectors were too expensive and could not be



Water from the distributing tank D. T. after flowing through the glass-covered troughs H.H.H. absorbing solar heat is stored in the storage tank S. T. This hot water gives up its heat in the vaporizer V and is sent back by the circulating pump C. P. to the distributing tank. Single-headed arrows indicate the flow of the water. Emergency steam boiler, B, for cloudy periods.
Sulphur dioxide flows in the direction of the double-headed arrows from the vaporizer coils to the engine E. The exhaust vapor goes to the condenser C. The liquid sulphur dioxide is returned by the feed pump F. P. to the vaporizer.
In practice the distributing tank is small; the storage tank S. T. holding both the hot and cold water.

Fig. 1. Diagrammatic Plan of Willsie Sun Power Plant.

made on a scale sufficient to the demands of commerce." Yet "Ericsson concluded that mirrors furnished the only possible means of concentrating solar heat for practical purposes and that silvered glass is best." John Ericsson began solar researches in 1868 and by 1875 he had constructed and started seven solar motors. During these years he was very enthusiastic, as the following quotations from his letters will show.

"The field awaiting the application of the solar engine is almost beyond computation."—"Who can foresee what influence an inexhaustive motive power will exercise on civilization."—"Upper Egypt with her never ceasing sun power will invite the European manufacturer to remove his machinery and erect his mills on the firm ground along the sides of the alluvial plain of the Nile, where an amount of motive power may be obtained many times more than now employed by all the manufactories of Europe."—"I shall never apply for any patent rights, and it is my intention to devote the balance of my professional life to its completion."

He employed a reflector of panes of silvered window glass set on a curve in a light movable frame work focused, in some of his models, upon a steam boiler and in other models upon an air chamber. He obtained by the use of steam a little better than 1 HP. from 100 sq. ft. of reflecting surface.

The Ericsson hot air pumping engine was the one commercial result of his solar experiments which cost him about $100,000. He finally wrote: "The scheme is impracticable on account of the great cost of the needed apparatus. The fact is, that although the heat is obtained for nothing, so extensive, costly and complex is the concentration apparatus that solar steam is many times more costly than steam produced by burning coal."

Perhaps because of the spectacular high temperatures, mirror arrangements held their popularity; and following Ericsson a number of inventors proposed, as shown in the patent records, various mirror concentrating arrangements to focus the sun's rays on various boiler equivalents, but I am unable to find any published record of any of these proposals having been put into operation until about 1898, when what is known as the Pasadena solar motor attracted considerable attention.

This device was notable because it was the largest and strongest of the mirror type of solar motor ever built. It was shaped very like an inverted umbrella. The umbrella ribs corresponding to the steel frame work supporting many small glass mirrors arranged to focus the solar heat upon a steam boiler corresponding in position, to the umbrella handle. The whole was nicely balanced and kept in focus by clock work. The diameter of the reflector was about 30 ft. and, I understand, the largest that could be built that would withstand wind pressures. Money and skill were liberally expended upon this plant. The 6 HP. usually developed by the machine was utilized to pump water on an ostrich farm, the lift being about 12 ft. The machine was dismantled some years ago. I am informed that the manufacturing cost of these machines was estimated at $5,000 each. Following this experiment Prof. R. H. Thurston, in an article entitled "Solar Energy," summed up the situation as follows:

"The probable value of the quantity of energy transmitted to the earth from the sun, according to the conclusion, after extended investigation, of the late Professor De Volson Wood, the greatest of American thermodynamists of the nineteenth century, is not far from that obtained by Langley—133 ft.-lbs. per sq. ft. of receiving area per second, about 133/550 = 0.24 HP., or the equivalent of 4 sq. ft. per horsepower. As actually utilized, Ericsson reported his solar engine to supply a horsepower from 100 sq. ft. of receiving area, on a bright clear day, and other experimentalists, with apparently less efficient apparatus, report a horsepower from about 150 sq. ft. of sunshine.

"This figure is confirmed by recent experiments at Pasadena, Cal., where it is said that the efficiency reached by Ericsson has in some cases been attained. Solar motors make available an immense quantity of active energy, by direct utilization. They are evidently practical in the sense that there is no inherent mechanical difficulty in their construction and operation. They are subject, however, to the defects of lack of steadiness of source of energy, of need for provision for extensive and prolonged storage, if to be generally employed, and to the serious objection of large cost per unit of power delivered. Whether this cost will be so great as to balance the gain coming from free delivery to the machine of the energy to be transformed can only be known when we are driven to the serious task of providing substitutes for the heat engines."

To the defects mentioned Prof. Thurston might have added another objection: the small size of the unit. The Pasadena experiment indicated that even 1,000 sq. ft. of mirror surface, delicately balanced to be kept in focus by clock work, was too large to withstand the wind pressures common in desert regions. And a maximum unit of say 10 HP. can scarcely be considered sufficient for modern power requirements.

At the St. Louis Exposition of 1904 an arrangement of mirrors designed by a Portuguese priest attracted some attention because of the high temperatures attained at the focal point and because of the absurd claims advanced. The reported statement that this device was able to prove the truth of Genesis (!) and the exploitation of it as the foundation of a new social order colony probably did not increase public confidence in the sun power problem.

The Direct Type.

The other type of solar motor, frequently proposed but not so familiar to the public, consists of a boiler exposed to the direct action of the sun's rays, an engine and a condenser. A liquid which has a low boiling point, as ether or ammonia, placed in the boiler will, during the middle hours of a bright day, afford a sufficiently high vapor pressure to operate the engine. The exhaust vapor is condensed and pumped back into the boiler.

According to my information, the first solar motor of this type was operated in Paris by Tellier at about the time Ericsson was experimenting. Tellier exposed 215 sq. ft. of heat-collecting surface and obtained but a small fraction of a horse power per hour. The scheme was patented in this country in 1880 by Molera, who, it was said, made some experiments. Since that time the patent records show a number of modifications of this type.

It is said that a plant of this type was built and operated in Morristown, N. J., by a Mr. Hayes in 1905. The largest installation of this type of which I have knowledge was built and operated at Tacony, near Philadelphia, by Mr. Frank Shuman in 1907. According to his descriptions the heater exposed 900 sq. ft. of heater surface to the sun and the engine developed about 3½ HP. Ether, the volatile liquid chosen,

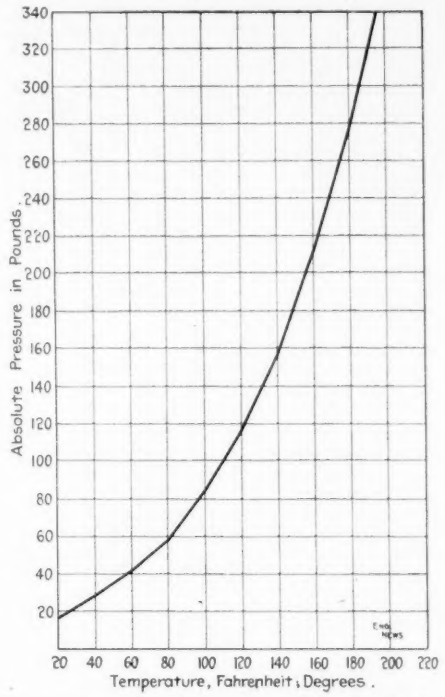


Fig. 2. Pressure-Temperature Curve for Sulphur-Dioxide Vapor.

was circulated in blackened pipes exposed, under a window glass covering, to the sunshine. The power developed operated a pump. Water was taken from a tub, elevated about 10 ft. and allowed to fall back into the tub to be again circulated.

Storage.

Practically every proposal for solar power is accompanied by some suggestion for storing a portion of the power developed from the sunshine for use during cloudy periods. With the first stages of the art the storage plans proposed were as simple as they were inadequate: as raising weights or water to subsequently operate gearing of some kind. Then tanks of compressed or liquid air, and electric storage batteries were proposed, as these arts were developed, but I have no information of any of these schemes having been put to trial. Of course all of these plans would have worked mechanically, but equally of course, none of them would have been adequate to meet any commercial requirement. All of these schemes proposed the storage of solar energy after it had been put into the form of mechanical motion. In his life of Ericsson, Church says: "To attempt to store up solar energy Ericsson devoted nearly as much time as to the solar motor, but no satisfactory result is recorded."

Indirect Storage Type.

One essential feature of this type is the storage of the solar heat before it is changed into the form of mechanical motion. To emphasize the importance of this "before and after" recall the mechanical equivalent of a heat unit: A pound of water raised one degree in temperature has stored up as much energy as a pound of water raised to a height of 778 ft. Another essential feature is the collection of solar heat from an extended area and the bringing of the heat to the boiler. The intermittent solar heat is absorbed and collected by some fluid, as water, that circulates under the glass of the heater. Light rays, which readily pass through glass, are changed by the water and the bottom of the heater into heat rays which cannot easily escape back through the glass. The solar heated water is stored in a tank, insulated to prevent the loss of heat by radiation. The heated water is then drawn uniformly and continuously from the storage tank and made to give up its heat by circulating it about a boiler containing some volatile liquid, as ammonia or sulphur dioxide. The vapor generated by this heat, after operating an engine, is condensed and returned to the boiler to be used again. The water, after giving up its heat to the sulphur dioxide, is sent out through the solar heater to again collect the heat in the sun's rays. Theoretically the plan meets all the requirements for the transformation of solar heat into continuous, uniform power. (Fig. 1.)

So far as I know, I was the first to propose this method, and Mr. Boyle and I are the only ones who have developed it by building operating plants. Although my first drawing of this plan was made in 1892, yet nothing was done, except some small experiments and some correspondence, until 1902. Mr. Boyle was then in Arizona, surrounded by conditions which daily remind one of the desirability of converting the over-abundant solar heat into much needed and costly power. To the Southwesterner "cheap power" brings visions of green growing things about his home to stop the burn of the desert wind, and of the working of the idle mine up the mountain side. Even the thought of artificial ice seems cooling.

Having decided on the undertaking it was first necessary to show that the solar heat could be collected and stored at a sufficiently high temperature. Our friends were skeptical about window glass being able to take the place of mirrors in a solar heater. Our first experimental heater was built at Olney, Ill. It consisted of a shallow wooden tank tightly covered with a double layer of window glass. The sides and bottom were insulated by enclosed air spaces filled with hay. The tank was lined with tar paper, well pitched to hold water to the depth of 3 ins. Although the weather was cold and raw, even for October, with occasional clouds, the thermometer in the water showed temperatures higher than were needed to operate a sulphur dioxide engine.

FIG. 3. WILLSIE SUN POWER PLANT AT THE NEEDLES, CAL.; INSIDE VIEW OF THE GLASS-COVERED BOILER HOUSE.

1, Distributing trough with perforated bottom; 2, stack of vaporizing pipes over which solar-heated liquid is flowing; 3, collecting trough (1, 2, and 3 are usually enclosed); 4, boiler used in experiment No. 3.

The next solar heater was built at Hardyville, Ariz. Sand was used for insulation. Three tests for the amount of heat gave these average results in December:

Test No.	Heat units absorbed per sq. ft. per hr.
1	120
2	122
3	148

An estimate showed that over 50% of the heat reaching the glass was absorbed into the water.

In 1903 some further heater tests were made, patent applications filed, and to carry on experiments on a more extensive scale the Willsie Sun Power Co. was incorporated.

In the spring of 1904 a complete sun power plant was built at St. Louis. In this installation a 6-HP. engine was operated by ammonia. The heater consisted of a shallow wooden basin coated with asphalt and divided by strips into troughs. It was covered by two layers of window glass and insulated at the sides and bottom by double air spaces. Each trough of the heater formed a compartment. The troughs were inclined so that a thin layer of water flowed from one trough to the next. In this heater was collected and absorbed into the water from the sun's rays 211,500 heat units per hour at noon, or 377 heat units per hour per square foot of glass exposed to the sun. As, according to accepted solar observations, about 440 heat units per hour reached a square foot of glass, this heater was showing the surprising efficiency of 85%, and collecting nearly twice as much solar heat per square foot per hour as did the apparatus of Ericsson. Of the lost heat I estimated that 40 heat units were reflected and absorbed by the glass and that 23 heat units were radiated. On cloudy days the water could be heated by burning fuel. A description of this plant appeared in a St. Louis paper and in a New York paper, but so far as I know it has not been mentioned in any technical publication.

It was then decided to build a sun power plant on the desert, and some land about a mile from Needles, Cal., was purchased for a site. Here, throughout the year, there is about 85% of sunshine, the air is practically free from moisture, and fuel is costly. For a volatile liquid, sulphur dioxide was chosen instead of ammonia, because the sulphur dioxide engine had been carefully tried out in Germany, and because it required less heavy pipe and fittings to withstand the pressures produced by the temperatures obtained from the heater. Our first sulphur dioxide had to be imported at considerable expense and delay, but with a suitable equipment it can be saved very cheaply at many places in the southwest as a by-product from sulphurous ores.

The building of this sun power plant was handicapped by all those conditions that must usually be met in erecting machinery in desert places. A heater consisting essentially of a concrete basin coated with asphalt and covered with glass was tried and the loss of heat from the bottom found to be too great. We had assumed that the desert sand would make excellent insulation; but the sand is not completely dry. There is a sort of capillary circulation of water sufficient to take away considerable quantities of heat from a concrete or asphalt bottom. A heater similar to the one we built at St. Louis, but with one layer of glass and with one insulating air space, was made and found to furnish ample heat. The condenser was of the submerged type built of one layer of pipe in a trough flat on the ground to allow the water pumped for irrigation to be the cooling water. The boiler part was built very like the condenser and on a level with the heater. A few days after this plant was started so much sulphur dioxide was lost through an accidental leak in one of the condenser pipes that further experiments had to be stopped. But enough had been learned to encourage us to build a larger plant.

The next or third sun power installation was built at the same place. A 20-HP. slide-valve engine was connected to an open-air water-drip condenser and to a fire tube boiler 22 ins. × 19 ft. having 52 1-in. tubes. The solar-heated liquid flowed through the tubes giving up its heat to the sulphur dioxide within the boiler. Boiler pressures of over 200 lbs. were easily obtained. The engine operated a centrifugal pump, lifting water from a well 43 ft. deep, and also a compressor, in addition to two circulating pumps. We planned to make artificial ice from solar heat, and the machinery for that purpose was on the ground. Then we ran out of money, and experiments with this plant were postponed for two years, until the spring of 1908.

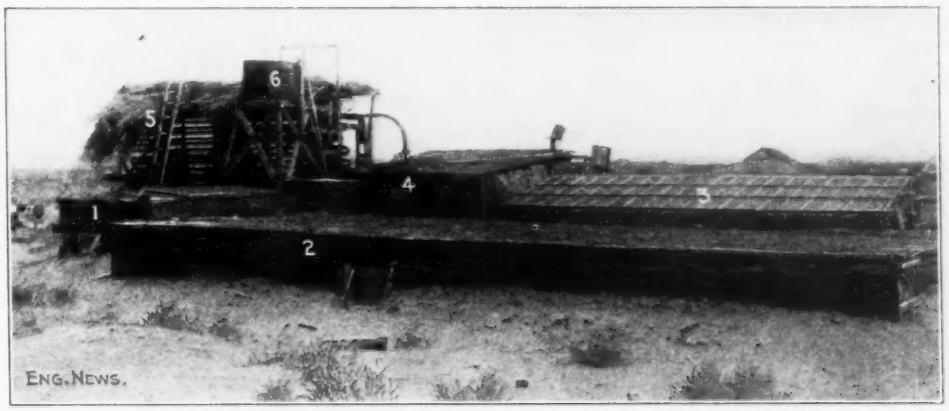


FIG. 4. THE WILLSIE SUN POWER PLANT AT THE NEEDLES, CAL. (NO. 4), WHICH RAN AT NIGHT.

1, Distributing tank; 2, first section of heater; 3, glass covered boiler-house; 4, engine shed; 5, condenser; 6, cooling water tank.

THERMOMETER READINGS.

Date.	Hour of the day. 7	8	9	10	11	12	1	2	3	4	5
June 19	118	148	190	214	233	243	249	242	230	212	190
" 20	110	138	...	...	...	247	246	238	228	...	188
" 21	120	150	195	220	236	248	251	...	232	211	188
" 22	121	148	180	218	234	249	250	240	229	208	...
" 23	120	141	193	217	232	243	...	243	233	212	193
" 24	126	147	195	221	240	254	256	247	238	216	195

This two years' exposure to desert conditions taught us something about the deterioration of this type of sun power plant. Only 2% of the glass was broken, but the putty holding the glass had dried and fallen away. A mixture of asphalt and crude oil remedied the putty trouble. Certain kinds of glass when exposed to the desert sun for a considerable time turn purple so as to prevent the passage of some actinic rays. Sulphur dioxide had been in the boiler engine and condenser these two years, and if there had been any leakage the loss was so slight as not to show on the gage glass. The sulphur dioxide had not injured any metal with which it had come in contact.

Our fourth sun power plant was a rebuilding of the third. One of the earlier heaters had been practically level with consequently slow circulation. At times oil was floated on one or more inches of water. With this plan we found that the collection of heat and the temperatures were less than when a thin layer of the heat collecting liquid was rapidly circulated. The heater in the fourth plant was in two sections, separated by a foot-path. The first section was covered by one layer of glass and the second section with two layers. Both sections were inclined. The heat collecting liquid ran from the first section into the second section, at the temperature of about 150°, and from the second section into the storage tank at about 180°. These temperatures varied with the time of day, wind, cloudiness and other weather conditions, and especially with the amount of liquid flowing through the heater. At the top of this column is a sample of the thermometer reading in a "hot box" with two layers of glass.

The high temperatures I consider remarkable, because Prof. Langley in southern California, using refined instruments, obtained 233° as a maximum noon temperature. Our several thermometers registered within one-half degree of each other and I considered them fairly accurate.

In the place of a boiler we used in this plant a heat exchanger (Fig. 3) built somewhat like a pipe condenser. The solar-heated liquid was distributed over the upper rows of pipes. The drop in temperature was quite regular, as the liquid ran down from row to row of the pipes. The liquid lost about 100° in its descent. This cooled liquid was sent back to the heater to collect more of the sun's heat. The exchanger was enclosed in a glass-covered shed. It was cheaper to build than a boiler and held less sulphur dioxide.

I use the term "heat collecting liquid" because our experiments included besides water, crude oil, a solution of chloride of calcium and air.

The pressure-temperature curve in Fig. 2 shows how well adapted is sulphur dioxide to use with temperatures obtained from this type of heater.

The engine used in this experiment was a vertical automatic cut-off, which at times, with a boiler pressure of 215 lbs., probably developed 15 HP. The two heater sections exposed an area of about 1,000 sq. ft. to the sun, but as the heat was taken from storage and not directly from the heater, it is not fair to assume the above proportion of heater surface to horse power developed.

The condenser consisted of six stacks of horizontal pipes, twelve pipes to the stack. The cooling water, pumped from a well 43 ft. deep, had a temperature of 75°. Only enough water was allowed to drip over the pipes to keep them wet, and so great was the evaporation in the dry desert breeze that the cooling water left the lower pipes at 64°. By using the cooling water over and over, the condenser gave very satisfactory results. A shade of arrowweed, a straight willow-like shrub abundant along the Colorado River, kept the sunshine from the condenser pipes and permitted a good air circulation.

Fig. 4 is a photograph of this plant. At times we would open the storage valve after dark, allowing the solar-heated liquid to flow over the exchanger pipes and thus start up the engine. This is the first sun power plant, so far as I know, that was ever operated at night with solar heat collected during the day, and has come nearer than any other plant built to the commercial utilization of solar heat for power purposes. It is also the largest sun power plant of which I have any record.

Granting that by this method heat from the sun received in varying and intermittent quantities can be transformed into uniform and continuous power the question still remains, "Will it pay to use it?" The following figures are taken from estimates which I made in a description distributed in 1904 as an answer to this question.

HEATER.—The cost of the heater is now estimated at about 25 cts. per sq. ft. of surface exposed to the sun. It is possible that this cost may be reduced to 15 cts.

On parallel 34° during a June day, about 2,300 heat units per sq. ft. will be received into the water, and during a December day about 1,600 heat units will be received. By building the heater to favor the December rays, an average of about 2,000 heat units per day per square foot may be obtained.

The sulphur dioxide engine, working within the range of temperature that can be had from the heater, requires about 30,000 heat units per horse power hour; or, 720,000 heat units per horse power for a 24-hr. day. Accordingly, 360 sq. ft. of heater surface will be required per horse power for a 24-hr. day. Or, allowing for storage accumulations, 400 sq. ft. per HP. of heater surface will be required for continuous running. The initial cost of the heater at 25 cts. per sq. ft. will thus be $100 per HP.; or, at 15 cts. per sq. ft., $60 per HP.

STORAGE.—Assuming that storage is provided for 100 hours and that the water is cooled through a range of 100°, the cost of the installation of the storage tank will be about $10 per HP. for a 400 HP. plant. The loss of heat from this size reservoir in 100 hours is estimated at one-half of 1% of the available heat stored. While, for explanation, separate reservoirs for hot and cold water are shown in the sketch, but one reservoir is required.

THE ENGINE.—The sulphur-dioxide engine, as an auxiliary to a steam engine has been brought to greater perfection in Germany than elsewhere. A 50-HP. engine has been running in Charlottenberg for nearly four years (1904). A 175-HP. engine is installed in the Berlin Electric Works, and a 450-HP. engine in the Machinen Fabrik Geb., Sulzer. In construction the sulphur-dioxide engine does not differ from the ordinary steam engine except in the more carefully packed stuffing boxes. "Sulphur-dioxide does not corrode the metal, it is very cheap and no lubrication of the cylinders is necessary."

The tests made by Prof. Josse with the 50-HP. engine have been widely published. The following are some of his figures:

Temperature sulphur dioxide vapor, Fahr. deg.	133.7
Temperature sulphur dioxide liquid, Fahr. deg.	66.
Temperature cooling water outlet, Fahr. deg.	70.
Temperature cooling water inlet, Fahr. deg.	50.
Pressure in vaporizer, lbs. per sq. in.	128.
Pressure in condenser, lbs. per sq. in.	33.
Area of condenser, surface sq. ft.	1,720.
Area of vaporizer surface, sq. ft. (using steam)	750.

The following costs of installation are given by Prof. Josse for a 400-HP. sulphur dioxide plant:

Engine, pumps, etc., per HP.	$20.00
Vaporizer, per HP.	6.00
Condenser, per HP.	15.00
Liquid sulphur dioxide, per HP.	1.25

In a sun power plant, the size of the vaporizer is increased to equal that of the condenser, and a small emergency steam boiler is provided to supplement the stored heat if necessary.

COST OF SUN POWER PLANT.—From the foregoing, the cost of installing a sun power plant may be estimated:

Heater, 24-hour size, per HP.	$100.00
Storage, 100-hour size, per HP.	10.00
Engine, pumps, etc., per HP.	20.00
Vaporizer, per HP.	15.00
Condenser, per HP.	15.00
Liquid sulphur dioxide	1.25
Emergency steam boiler	2.75
	$164.00

In a table before me, the costs of steam power plants range from $40 to $90 per HP. The cost of a sun power plant is accordingly from two to four times that of a steam plant and the interest and depreciation on this excess of cost offsets in some measure the saving in fuel.

Our experience indicated that sun power plants should be built in large units to distribute their power in the form of electricity. In the following comparison of power costs, the rate of coal consumption, although high, is not unusual in localities favorable to the operation of sun power plants. The wages of a fireman may be saved, and as the general operation is quite automatic the general labor item may be less. The saving in cylinder-oil will more than equal the expense for sulphur-dioxide. Comparison of costs per horse power per hour in 400 HP. steam-electric and solar-electric power plants:

Cost of One Electric HP.-hr., Cents.	Steam.	Solar.
Engineer, 40 cents per hour	.08	.08
Fireman, 30 cents per hour	.06	...
Dynamo man, 40 cents per hour	.08	.08
Helper, 25 cents per hour	.05	.05
Superintendence,	.06	.06
Coal	1.5	...
Int., maintenance, deprec. power plant.	.046	.184
Int., maintenance, deprec., electric plant.	.006	.006
Oil, waste, water (or sulphur dioxide)	.15	.15
Total, estimated steam plant at $40 per HP.	2.078	
Total, estimating solar plant at $164 per HP.		.610

On this basis a steam plant must obtain its coal for 66 cts. a ton to compete with a sun power plant in districts favorable to sun power plants; and the above sized sun power plant would pay for itself in less than two years.

To the criticism that sufficient allowances for losses in the solar plant have not been made, it may be said that some sources of gain have not been included. For instance, many steam plants running 24 hours have four periods daily of an hour each during which there is little use of power and a continued consumption of coal. And in general the production of power is irregular, while the consumption of coal is regular. In a sun plant only so much heat is taken from storage as is needed to maintain the required vapor pressure. During the summer months there will be an excess of sun power of 25% that may be profitably used for the manufacture of artificial ice.

When the above comparison was written, in 1904, steam was the cheapest power in the desert country, but within the last two years the producer gas engine has been successfully used at a number of southwestern mines, developing a horse power for a little more than a pound of coal an hour. Using this coal consumption in the above comparison a producer gas engine must obtain its coal for about $2 a ton to produce power as cheaply as a sun power plant in localities favorable to the solar installation.

However, there are a sufficient number of existing demands for sun power if the above estimates prove in practice to be approximately correct. One mine in Mohave County, Arizona, has a fuel bill of about $72,000 yearly. The fuel is hauled 20 miles over the desert and then 5 miles over a mountain range. Another large mine cannot get coal for less than $15 a ton. In one valley nearly 5,000 HP. could be used in mining. In most of the small desert towns there is a demand for artificial ice that warrants a factory.

For many years this desert country must be sparsely populated for much of it cannot be irrigated; the geological reports do not indicate any probable finds of fuel, and the freight hauls are long. Here to my mind is the field for sun power Here each experiment leading to something tangible will receive encouragement and support.

The Failure of a Portion of a Steel Tower Electric Transmission Line in California.

By EDWIN DURYEA, JR.,* M. Am. Soc. C. E.

On Jan. 20, 1909, during a protracted rainstorm accompanied by heavy wind, about eleven miles of the tower-line of the Great Western Power Co., near Sacramento, Cal., were blown down; in the same storm about a mile of line more further north, near Bear River, and another mile still further north, between Marysville and Oroville, were also wrecked. At the request of Engineering News, the following short description of the line and its partial failure is written.

THE TRANSMISSION LINE.—The power-house of the Great Western Power Co. is at Big Bend, on the Feather River, about 14 miles above Oroville, Cal.; and its transmission-line extends thence through Sacramento to Oakland, a total line-length of about 160 miles. A duplicate tower line is being erected, but as yet there is but a single line.

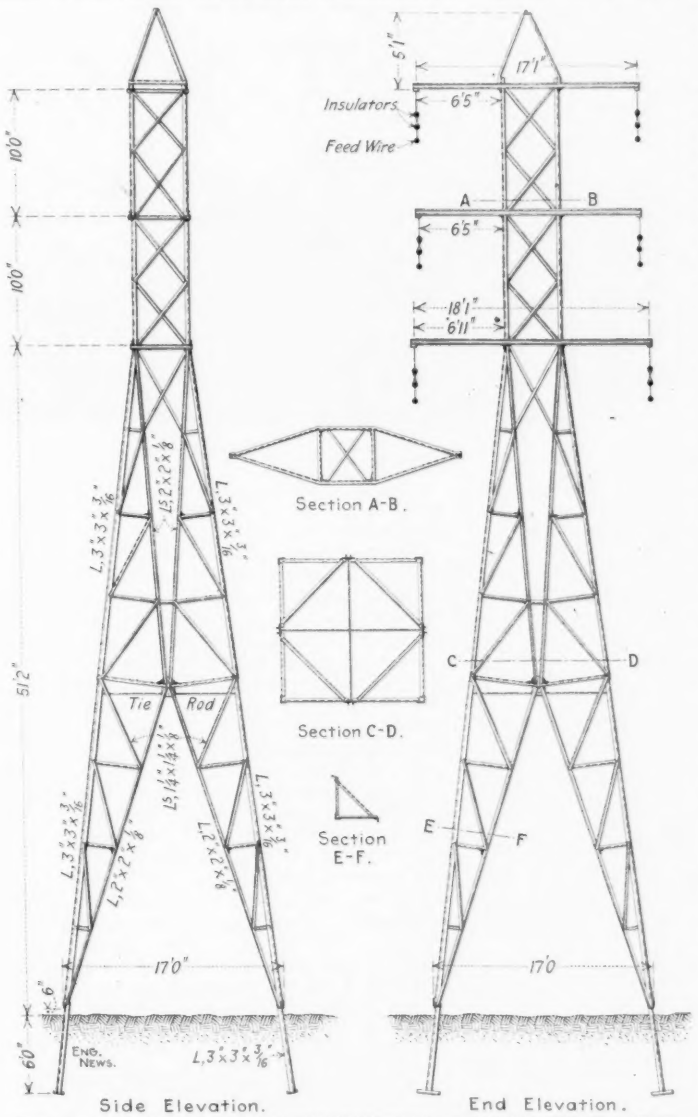


FIG. 1. DETAILS OF THE TRANSMISSION TOWERS THAT WERE OVERTHROWN.

The tower-line carries two circuits (6 conductors) of stranded copper cables hung to suspended insulators, also a steel "ground wire" strung along the apex of the towers; each cable being equivalent to a No. 000 copper wire. The normal spacing of towers is 750 ft., or about 7 spans per mile, and the metal-weight of a complete standard tower is about 3,800 lbs.

The generator installation in the Big Bend power-house is 40,000 KW. in four equal units. When the tower-line failed the portion covering the longest break was complete with all six cables and with ground-wire, and was carrying current; but from one 10,000 KW. unit only, the others not having been completed.

THE TOWERS.—The towers are built of structural steel angles and channels, with bolted joints, all the pieces being galvanized as a protection against corrosion. The shape and dimensions of a "standard tower" are shown by the erection diagram, Fig. 1, and in the several half-tones. As shown, the battered portion of the tower is formed of four parts identical in design, each part composed of two triangular pyramids placed base to base, with one apex at ground-level and the other at the base of the upper rectangular portion of the tower, called the "cage."

Some apparent structural defects in the design of the tower could be pointed out, but as the failure of 13 miles of the line was due to a weakness in the foundations instead of in the steel frame, a discussion of the latter seems unnecessary in this article. The apparent structural weaknesses in the frame work may even have been intentional with the designer. The end sought in a steel bridge design is a general uniformity of strength in all the members, with a little excess of strength in the details; but in a very light-weight structure, such as these transmission-towers, it may be that a least total cost can be secured (because of a large saving in shop work, etc.) by allowing an excess of weight and strength in some parts of the structure, in which case a structure of unequal strength would be in strict accordance with the principles of good engineering design.

CAUSE OF FAILURE.—As just stated, the cause of the failure seems to have been in the foundations. It seems to have been due, also, to defects in the construction of the foundations rather than to their design, though the latter probably contributed somewhat to the failure. These foundations consisted merely of an extension of the tower leg, transmitted with a transverse channel, some 6 ft. into the earth.

The long stretch which failed, near Sacramento, begins where the line leaves the "tule" land (a deep marshy alluvium of a peaty nature, covered by a growth of tules or bull-rushes, etc.), and extends northward on firmer ground for a distance of about 11 miles. For 22 miles south of the break the line is located on tule land, with all the towers on pile and concrete foundations; the foundation of each tower consisting of four wooden piles (one under each tower-leg), each pile surmounted by a concrete block. The piles average about 12 ft. in length. The concrete block above each pile is about 8 ft. in height, 2 ft. square at its top, 2 ft. × 5 ft. at its base, somewhat unsymmetrical in shape, and contains about 1½ cu. yds. of concrete. The piles are cut off just below water-surface, and the top of the pile is embraced by the concrete block and tied to it by two loops of iron. The "stub" of the tower-leg extends downward into the concrete block.

The line failure began with the first tower not supported on such pile and concrete foundations and extended northward for eleven miles until it was stopped by a "special tower" of greater strength and weight than the "standard" towers. Eighty-one consecutive towers are said to have failed in this stretch, and 92 in all. That the towers did not fail merely because of the lack

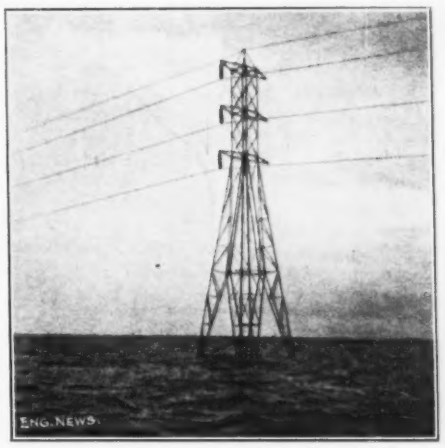


Fig. 2. Tower in Use, Showing Heavy Overflow of Land From Floods.

of pile and concrete foundations is made certain, however, by the many miles of line (aggregating nearly 900 towers), both north and south of the main break and the stretch with pile foundations, which have nothing but the stub footings and which withstood without injury the storm causing the break. In some instances, in the foothills, towers which withstood the storm are said to be spaced as much as 800 to 1,000 ft. apart, though only standard towers with ordinary stub foundations.

The real cause of the failure seems to have been careless and faulty setting of the stubs. Where

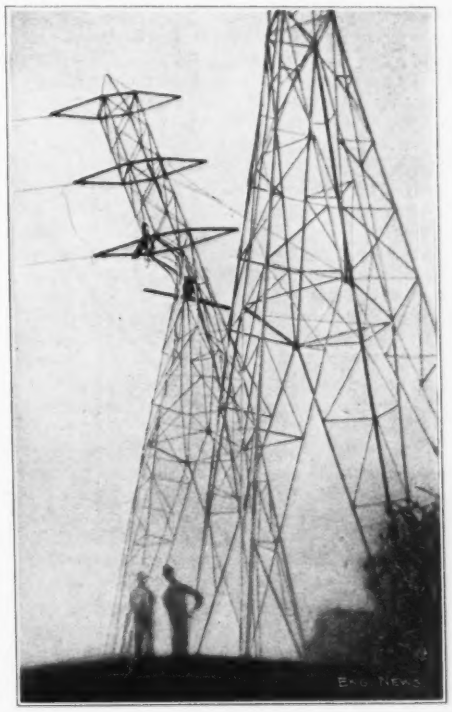


Fig. 3. Collapse of One of the Towers During Construction, Due Probably to Improper Temporary Guying.

the failures occurred the ground is much of it a form of adobe, a clay which is very hard when dry and a sticky mud when broken up and softened by water. The towers were erected in the summer and fall of 1908, when the ground was so dry and hard that most of the stubholes were

*Duryea, Haehl & Gilman, Civil and Mining Engineers, 1315 Humboldt Bank Building, San Francisco, Cal.

TABLE SHOWING ELEMENTS OF SEVERAL HIGH-VOLTAGE, LONG-DISTANCE TRANSMISSION LINES.

Power Co. and year designed.	Location.	Length of transmission.	Voltage.	Kilowatts transmitted.	Phase and No. of circuits.	Conductor.	Spacing of conductors.	Height of standard tower and span.	Width of tower at right angle to line.	Distance nearest tower member to line.	Type and Number of insulators.	Highest and lowest wires from ground.	Weight of complete tower.	Coating of metal in tower.	Tower Foundations.
Great Western Power Company. 1907.	Northern Central California.	100 miles. Big Bend to Oakland.	100,000	40,000 with first development.	3 phase. 2 circuits.	No. 000 copper strand cable, 6 wires and hemp core to a strand.	10 ft. vertically.	76 ft. in height. 750 ft. span.	17 ft.	6¾ ft.	4 50,000 vt. suspended lock type for each conductor	93 ft. * 46 ft. *	3,800 lbs.	Galvanized.	Angle posts feet into flat steel channel plate.
Stanislaus Electric Power Co. 1907.	Central California.	92 miles to Mission San Jose. 140 miles to San Francisco.	100,000	5,500 at present. To be increased shortly to 10,000.	3 phase. 1 circuit.	No. 0000 strand copper cable with hemp center.	8 ft.	65 ft. in height. 800 ft. span.	15 ft.	3 ft.	Suspended type—Lock and G. E.	58 ft. 35 ft.	3,400 lbs.	Galvanized.	Wrot iron saddle bolts to the tower leg at ground surface, and two angles go down into the ground fastened at bottom and bolted to flat channel plates.
Edison Electric Co. Kern River No. 1. 1906.	Southern California.	117+ miles	60,000 now. Intend to raise to 80,000.	30,000, including 50% over load at peak.	3 circuits.	No. 0000 hard drawn copper 7 strand. Elastic limit 35,000 lbs. Tlt. strength 42,400 lbs. 2,500,000 lbs. of cable used in the line.	6 ft. between wires.	300 to 600 ft. 1,140 towers in 117 miles av. span is $\frac{117\times5280}{1140}$ = 542 ft.	12 ft.	3 ft.	Pin type, C. I. pin, 3 petticoats, 9 to the tower.	61 ft. 55 ft.	4,250 lbs. average.	Galvanized, portions below ground asphalted.	No concrete used. Foot plates of C. I. 24 in. diam. dipped in asphalt.
Sierra Light and Power Co. 1906.	Mexico.	159 miles.	60,000	37,500 at peak.	3 phase. 4 circuits. 2 tower line.	No. 0000 $\frac{1}{2}$ in. diam. hemp center copper strand cable, 40,000 lbs. Elastic limt, 90,000 lbs. Tlt. strength, 108,000 circular mills section.	Circuits carried on 6 ft. triangles.	Span not given.	14 ft.	2 ft.	Pin type, porcelain petticoats, 14 in. diam. 120,000 vt. test.	46 ft. 40 ft.	.....	Galvanized.	Tower legs connected to a C. I. plate 6 ft. below the ground surface.
Winnipeg Power Co.	Canada.	65 miles.	60,000	.....	3 phase. 2 circuits.	No. 00 hemp core cable No. 7 wires.	6 ft.	Span 400-500 ft.	.....	.....	Pin type.	60 ft. 40 ft.	2,240 lbs.	.....	.....

opened up by blasting. It is said that many of these holes were refilled hastily and carelessly after setting the stubs, with lumpy material insufficiently compacted; when the hole had been blasted too deep the foot-plate sometimes resting on loose refilled material. It rained almost without intermission throughout January, resulting in river-floods which overflowed much of the land where the line-failure occurred; and the rain and the overflow so softened up the looose refilled material in the holes as to destroy its lateral support to the stubs, and in some cases its vertical supporting power and even its holding-down power. The great lack of stiffness in the joint between the foot of the leg and the top of the stub made a lateral support to the stubs especially necessary, and the most general cause of the tower failures is believed to be the pushing over the stubs by the force of the wind, due to their lack of lateral support. It is not believed that any breakage of the cables caused the failure, or even that the failure was accompanied by such breakages.

WIND PRESSURE.—Where the long break occurred the transmission-line bears a little east of north, and the wind during the storm which caused the failure was from southeast to south. From the U. S. Weather Bureau records at Sacramento, the maximum velocities of the wind on Jan. 20, 1909, for periods of five consecutive minutes, were as follows:

9—10	A. M.,	26	miles per hr.	=	3.4	lbs.* per sq. ft.
10—11	"	28	" " "	=	3.9	" " " "
11—12	Noon,	26	" " "	=	3.4	" " " "
1—2	P. M.,	26	" " "	=	3.4	" " " "
2—3	"	37	" " "	=	6.8	" " " "
3—4	"	36	" " "	=	6.5	" " " "
4—5	"	44	" " "	=	9.7	" " " "
5—6	(5.17)	48	" " "	=	11.5	" " " "
6—7	P. M.,	45	" " "	=	10.0	" " " "
7—8	"	40	" " "	=	8.0	" " " "
8—9	"	35	" " "	=	6.1	" " " "
9—10	"	26	" " "	=	3.4	" " " "

*lbs. per sq. ft. = (Vel. in miles per hr.)^2 × 0.005. Formula said to have been derived by Smeaton, for windmill practice.

The wind was from a southeast direction until 7 p. m., and after that from the south. It is characterized as "brisk to high, with occasional heavy gusts." The first tower-failure is said to have occurred at 3.52 p. m., and the other towers to have failed between then and about 5 p. m.

The maximum wind-velocities recorded at Sacramento from July 1, 1877, to Dec. 31, 1900, are as follows:

27	winds	exceeding	40	miles	per hr.
121	"	"	30	"	" "
217	"	"	25	"	" "

The above winds include the following:

5	at	48	miles	per hr.	=	11.5	lbs. per sq. ft.
1	"	51	"	" "	=	13.0	" " " "
2	"	60	"	" "	=	18.0	" " " "

The only wind records at hand since 1900 are for the Januarys from 1901 to 1909, inclusive. These records show maximum wind-velocities as follows:

6 winds equalling or exceeding 40 miles per hr.
1 wind at 45 miles per hr.
1 " " 48 " " "
1 " " 60 " " "

From the wind-velocities given, it appears that the line-failure occurred during a windstorm of less severity than many of which had been recorded. However, as the failure occurred in the foundations, and as very many of the standard towers with ordinary stub-foundations withstood the storm without injury, the wind-pressure during this storm has but little interest in connection with the design of the steel frame.

In comment on the possible local variation between the wind-velocity at Sacramento and that where the line was blown down, any variation of importance is quite unlikely. The southern end of the long break was within six miles of Sacramento, in the northern-central portion of a flat plain (the Great Valley of California) nearly 50 miles wide east and west and more than 300 miles long north and south. The wind was from the southeast and south and the wind conditions at the break could not have differed materially from those at Sacramento.

It is notable that the storm which caused the failure of about 13 miles of this transmission-line left 147 miles of the line (only 22 miles of which were on pile foundations) uninjured; also that it did no damage to the wooden pole-lines (60,000 volts, etc.) of the California Gas & Electric Corporation which closely parallel the Great Western line, though some of these wooden pole-lines are far from new. Also that the tower-line of the Stanislaus Electric Power Co., crossing the Valley about 75 miles further south and equally exposed to the storm, was not injured by this wind.

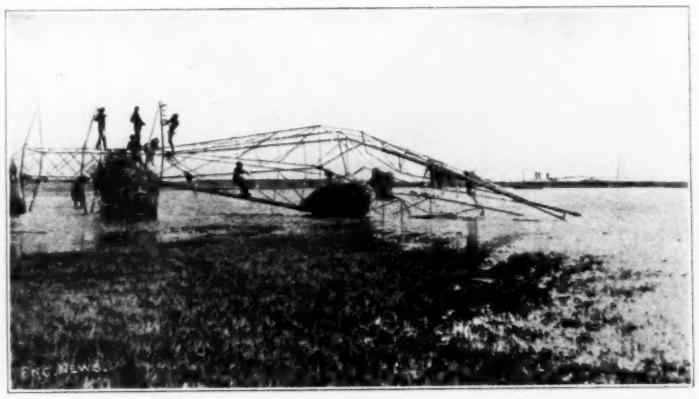


FIG. 4. ONE OF THE COLLAPSED TOWERS.

Comparatively little interruption to the power of the Great Western Power Co. was caused by the line-failure. A large proportion of their power was being sold to the California Gas and Electric Corporation and delivered to the lines of the latter company near Oakland; and when the break occurred the point of delivery was changed to Oroville. Since then the breaks have been spanned by wooden pole-lines and the Great Western Power Co. are again delivering their power to Oakland over their own line. It is reported that they are also making general improvements throughout their transmission-line.

As matters of general interest in connection, the accompanying table gives the principal elements of several long, steel-tower high-voltage transmission lines, including those of the Great Western Power Co. and the Stanislaus Electric Power Co. It should be stated that while the lines of these two companies are intended to be operated at 100,000 volts, they are as yet carrying 60,000 volts only; the small amounts of power thus far produced and the sale of power by both companies to a third company operating at 60,000 volts making a higher voltage as yet unnecessary.

Calorific Value of California Fuel Oil.

By R. W. FENN,* M. Am. Soc. C. E.

The accompanying tabulated comparison of California crude oils of different densities has been compiled by the writer from a very large number of laboratory and running tests made by various chemists and practical experts. The primary object in preparing this table was to ascertain definitely whether there was any absolute connection between the density, as indicated by degrees of the Baume scale, and the calorific value of the oils. The result of a careful digestion and comparison of the data secured from diverse, but reliable sources was the justification of the belief that a perfect sliding scale would quite accurately conform to practical calorific values.

It must be borne in mind, however, that for practical purposes no table can be made more than closely approximate in character, owing to the great variety of methods used in burning the oil, the efficiency of some methods being con-

*Agent, Union Oil Co. of California, Apartado No. 288, Panama, R. P.

siderably greater than that of others, and owing also to the intermittent character of tests made with the same burner and equipment, due to clogging of burners, change of draft, or the personal equations of those in charge of the plant.

The writer cannot at all agree with the conclusions of the U. S. Naval "Liquid Fuel" Board, as incorporated in their report of 1904, in regard to one important point. Quoting from the report, p. 417:

> It will be found, practically that the thermal efficiency of a pound of oil is the same whether the oil be crude or refined. While the crude oils contain sulphur and other chemical elements that are low in thermal efficiency, they contain substances that are particularly rich in hydrogen. In the process of distillation not only the sulphur but the rich hydrocarbons are lost, and it can thus be expected that in the commercial burning of oil as a fuel the evaporative efficiency of the same weight of oil from every field or district will be practically the same.

The writer maintains that this conclusion is based on insufficient evidence. According to the report, only two kinds of oil were used during a series of tests and experiments extending over a period of two years or more, viz., refinery residuum ("flash" or "topped" oil) from Texas, and Kern County oil from California. We are of the decided opinion, judging from experience, testimony of experts and records of tests, that the table given herewith is correct only for crude oil and not for "topped" oil. The "topped" oil is not *necessarily* more valuable in proportion to its greater density, but the crude oil is more valuable when heavier.

This question has been fruitful of argument, and it is probable that the chief, if not the only, reason for any difference of opinion on the subject has been that the quality of the oil was not always distinguished; hence, each party to the argument was sure of the force of his logic, but did not have the foundation facts at his command.

The accompanying table is not only for the purpose of comparing oil with oil, but also oil with coal.

The first column shows the density by the capricious Baume scale. The second column gives the corresponding specific gravity. The third column gives the weight per barrel. The fourth column contains the result of the compilation of all available data in regard to the calorific value of the crude oil reduced to a regular scale and expressed in B.T.U. per pound of combustible. The last column is the product of the preceding two, but does not exactly agree with them because the decimals have been dropped in the third column, from the weights per barrel.

It is evident from the figures given in the table that, the thinner the crude oil, the more heat per pound, but the less heat per gallon. To make comparisons with coal, it is only necessary to multiply the number of B.T.U. per pound of the coal by 2,000 or 2,240, according to whether one is figuring on short or long tons, and to obtain the ratio of this product to the figures in the last column of the table.

COMPARISONS OF COAL WITH CRUDE OIL.—In using the table for comparing oil with coal, allowance should be made for the difference between the efficiencies obtainable with the two kinds of fuel under actual working conditions. The results quoted below from a number of different authorities may give an idea of what can be expected from California fuel oil under various conditions of service.

The Stirling Co., in their "Book on Steam for Engineers," p. 126, comment on a table of calorific ratios between barrels of oil and tons of coal as follows:

> This and all similar computations based upon the relative calorific power of petroleum and coal are of no practical value, for the reason that when burning oil an efficiency ranging as high as 83% can be obtained with large boilers of good design, while with poorer grades of coal and smaller boilers the efficiency may fall to 65% or lower. The efficiency of either fuel will depend upon the size of the boilers, the adaptation of their grates and furnaces to the particular used, the degree of intelligence of the men in charge, and other similar factors.

Following this, however, are given some results of actual running tests on which to base estimates. An average of two tests at the Los Angeles Gas & Electric Co.'s plant, lasting 12¼ hours, gives an evaporative effect of 14.576 lbs of steam per pound of oil. The quality of the oil was "poor," being heavily loaded with water in suspension, but it is not stated what was its density by the Baume scale. A comparison with Pittsburg, 3rd Pool, Lump Coal, evaporating 10.47 lbs. steam per pound of fuel, or about the same as Cumberland Coal, will give a relation of 4.4 bbls. of oil equal to one short ton of coal. In table 60, p. 208, the same book gives the results of other tests much more favorable to the oil.

In "Foster's Electrical Engineers' Pocket Book," 1908, p. 1358, is found a table showing comparative costs of oil and coal and based on a 322-lb. barrel of Texas oil and a long ton of Pocahontas coal. The evaporation of the coal is given as 10 lbs. and of the oil as 14.8, with the consequent ratio (B.T.U. per ton of coal to B.T.U. per barrel of oil) of 4.70 to 1.

Referring again to the U. S. Navy tests comparing Texas Residuum and California (Kern County) oil with Pocahontas coal, the calorific value of the California oil, 15° Baume, being given as 18,667 B.T.U., the final summing up is as follows:

> The relative evaporative efficiency of oil and coal as a fuel, as determined by this extended series of comparative experiments, is practically in the proportion of 15 to 10. The actual superiority of oil will be considerably greater, for in the coal experiments unusual skill was exercised in the management of the fires. Lump coal of superior quality was used; and as the tests with coal were of comparatively short duration, the resulting loss from cleaning fires was much less than would occur in actual service. The oil experiments, however, were carried on under conditions that more closely approximated those that could be secured on board the seagoing vessel. The actual evaporative efficiency of a pound of oil as compared with a pound of coal will therefore be in the ratio of 17 to 10, and these figures can be regarded as substantially correct.

The Naval Board also makes the following statement:

> Probably no more striking way of showing the relative commercial value of coal and oil as a fuel could be presented than by stating that the Atchison, Topeka and Santa Fe Railway Co. made, the following comparative tests, of the cost per train mile, of coal costing $6.65 per ton and petroleum costing $1.33 per barrel:
>
> Twenty-five passenger and freight engines on a 30-day run used 2,077 tons of oil and traveled 87,063 miles, or 41.9 miles per ton, or 3,500 miles per month per engine. Oil at $1.33 per barrel would, at this figure, cost 14.4 cts. per mile. Twenty-five passenger and freight engines (same days, same track and same conditions), burning coal, cost 23.2 cts. per mile. The oil was 15° Baume, about the same as the Kern River oil, which is 14° to 17° Baumé; this showed a saving for oil of 38%, and the experiment was tried with coal at $6.65 per ton.
>
> In this extended and practical test the cost of the oil per barrel was one-fifth of the cost of the coal per ton, while the resulting gain for oil was 38%. Stated in another form, the value of the two fuels would be the same when the price of the coal in tons was 3½ times the price of the oil in barrels.

California crude oil of densities varying from 23° to 25° Baumé, has been used by the Isthmian Canal Commission for nearly two years, on its stationary and floating plant, in competition with Pocahontas coal. Quoting from an article on "Crude Oil as Fuel" in the Canal Record (official organ of the Commission) of Nov. 11, 1908, Vol. II., No. 11:

> "As the oil costs 90 cts. a barrel, the saving from a fuel point alone will be 56%. In addition to this, the fixed expenses, such as wages of firemen, etc., are considerably less."

This is in comparison with the Pocahontas coal at $6.35, and therefore represents a calorific ratio of 3.1 to 1 between a ton of coal and a barrel of oil. This is due in part to the slacking of the coal and consequent waste in the draft as well as loss of calorific value and loss in handling. The heads of the Mechanical Department do not endorse this statement, but claim that a ratio of 4.3 to 1 is correct, but it is questionable whether they give the oil the full benefit of all its economies.

In another article in the Canal Record, Oct. 28, 1908, Vol. II., No. 9, p. 69, referring to the Culebra Cut compressed air system with a total maximum output of 1,800,000 cu. ft. of free air per hour, we find the following:

> The fixed charges for the three plants are $65, and the cost per day for coal is $244. Oil-burning apparatus has been installed, and as soon as the plants begin to use oil as fuel the fixed charges per day will be reduced $21 a day, and the fuel charges $100 a day, making a total reduction of $121 per day.

The saving here promised is evidently based on results already obtained and amounts to 39.1%. The saving in fixed charges is indicated as approximately 9% of the total expense for coal.

Referring to "Kent's Mechanical Engineers' Pocketbook," edition of 1905, p. 636, we have the average calorific value of two samples of Pocahontas coal as follows:

Percentage ash.	B. T. U.
3.2	14,603
6.2	13,608
Average.....	14,106

Which, being a laboratory test, is undoubtedly much more favorable for the coal than actual practice. Hence, according to these figures, one ton (2,000 lbs.) would have 28,212,000 B. T. U. According to accompanying table showing approximate relative values of California petroleum, which I have compiled from an exceedingly wide range of practical tests under all kinds of boilers, we have, for the 23° Baumé oil which the Commission have been receiving, 6,153,426 B. T. U. per barrel. Dividing 28,212,000, the number of heat units in a ton of Pocahontas coal, by 6,153,426, the number of heat units in a barrel of this oil, we have a ratio of 4.5 + to 1. In this case we have not deducted for the saving on fixed expenses, nor for waste and slacking of coal, nor for the difference between laboratory tests and actual practice with coal.

On page 925 of the first volume of the "Hearings Before the Committee on Inter-Oceanic Canals of the United States Senate," Document No. 401, figures given by the Gulf Refining Co. to Mr. T. P. Shonts in 1905 show that the Pennsylvania Railroad Co. finds that oil at $1.95 per barrel would be about equal to coal at $6.35 per ton. This is, of course, Pittsburg coal, which is certainly equal to Pocahontas coal on the Isthmus of Panama. They also state that "a pound of petroleum is as good as 2 lbs. of coal." The Santa Fe Railway engineers also have a general formula, that 1 lb. of oil equals 2 lbs. of coal.

The report of the California State Mining Bureau gives the calorific value of California oil at an average of 18,900 B. T. U., which confirms the figures given in the accompanying table. The reader is referred also to a paper by Prof. Edmond O'Neill, of the University of California, published in the Journal of the American Chemical Society, July, 1903, in which he gives a table showing the result of a careful investigation of the same subject and confirming the preceding general statement.

On p. 69 of the mining bureau's report, a table is given showing the relative cost of a long ton of coal as compared with 4 bbls. of oil, which is assumed to be the well recognized standard equivalent. Compare with this the following results of a series of careful locomotive tests by the Santa Fé Railway: Two samples of Beaumont, Tex., oil gave an evaporation of 13.62 lbs. of steam; two samples of Virginia coal gave an evaporation of 8.73 lbs. According to these results, one short ton of coal would evaporate 17,460 lbs. of water, and 4 bbls. of oil (321 lbs. to the barrel) would evaporate 17,488 lbs. of water. This shows 4 bbls. of oil to be equivalent to one short ton of coal, by actual running test.

Finally,* it might be well to add some data obtained by the California State Mining Bureau from official sources, showing the results of a year's work on a number of bay and river steamers in California, in which a general comparison was made between many different grades of oil and the usual grade of marine steam coal obtainable in the vicinity of San Francisco. The figures are furnished for seven steamers, with the following results for the entire year:

Steamer No.	Bbls. of oil equal to one ton coal.
1	3.59
2	4.06
3	3.72
4	2.78
5	3.46
6	3.20
7	3.27

The conclusion is that there seems to be just such uncertainty in results as is indicated in the foregoing quotations from "A Book on Steam for Engineers," and for the reasons given therein, but the general correctness of the table given

*Reports of tests showing comparative evaporative value of fuel oil will be found in Eng. News, 1902, Jan.-June, pp. 80 and 501; 1902, July-Dec., pp. 122, 124, 305, 349; 1901, July-Dec., p. 23; 1900, July-Dec., p. 305.—Ed.

herewith cannot be reasonably called in question, and, therefore, it is believed that it may be of some service to those interested.

CALORIFIC VALUES OF CALIFORNIA FUEL OILS.

Degrees Baume.	Specific gravity.	Weight per bbl.	B. T. U. per lb.	B. T. U. per bbl.
10	1.0000	350.4914	18,380	6,442,006
11	.9930	348.	18,440	6,417,868
12	.9861	346	18,500	6,393,970
13	.9791	343.	18,560	6,370,035
14	.9722	341.	18,620	6,345,324
15	.9658	339.	18,680	6,323,180
16	.9594	336.	18,740	6,301,512
17	.9530	334.	18,800	6,279,576
18	.9466	332.	18,860	6,257,371
19	.9402	330.	18,920	6,234,708
20	.9339	327.	18,980	6,212,534
21	.9280	325.	19,040	6,192,950
22	.9222	323.	19,100	6,173,500
23	.9163	321.	19,160	6,153,426
24	.9105	319.	19,220	6,133,486
25	.9047	317.	19,280	6,113,495
26	.8989	315.	19,340	6,093,260
27	.8930	313.	19,400	6,072,006
28	.8872	311.	19,460	6,051,282
29	.8814	309.	19,520	6,030,118
30	.8755	307.	19,580	6,008,319
31	.8702	305.	19,640	5,990,200
32	.8650	303.	19,700	5,972,646
33	.8597	301.	19,760	5,954,083
34	.8544	299.	19,820	5,935,297
35	.8492	298.	19,880	5,917,083
36	.8443	296.	19,940	5,900,645
37	.8395	294.	20,000	5,884,800
38	.8346	293.	20,050	5,865,026
39	.8299	291.	20,100	5,846,487
40	.8251	289.	20,150	5,827,179
41	.8204	288.	20,200	5,808,308
42	.8157	286.	20,250	5,789,475
43	.8110	284.	20,300	5,770,275
44	.8063	283.	20,350	5,750,910
45	.8017	281.	20,400	5,732,196

Hydraulic Gate Valves for the Chicago Water-Works.

Gate valves operated by hydraulic cylinders are in use at some of the pumping stations of the Chicago water-works system. The object of using hydraulic valves at these points is to allow of quick operation and to avoid the necessity of employing a gang of men to operate the gate. It would probably be unwise to install large gates capable of such quick closing on outside mains, on account of the danger of water hammer. But at or near a pumping station, where the gates are directly under the charge of the engineer of the station and are operated with good judgment, it is considered that no harm should result from their use, while the quick operation is often of value. It is considered that the saving in the expense of calling a gang of four or six men to operate these gates each time would soon pay for the extra cost of the hydraulic attachment. This cost is about $200 to $300 for gates of 36 ins. to 48 ins. diameter. Fig. 1 shows a 48-in. hydraulic gate valve at the 14th St. pumping station.

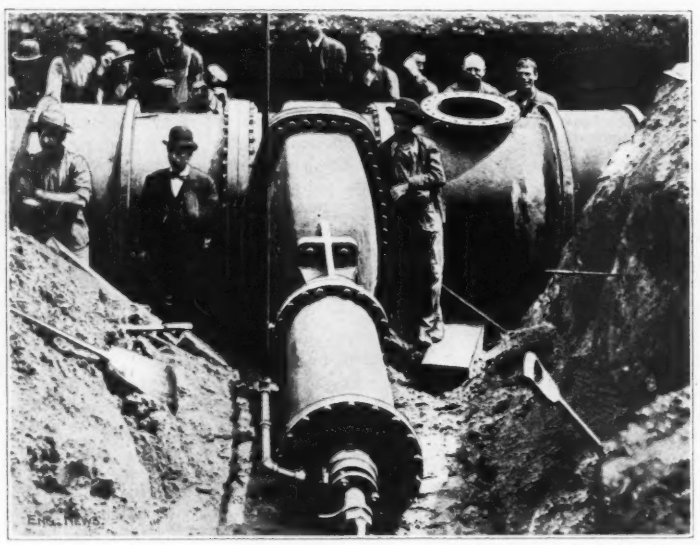


FIG. 1. 48-IN. HYDRAULIC GATE VALVE ON A DISCHARGE MAIN OF THE 14TH ST. PUMPING STATION; CHICAGO WATER WORKS.

The general arrangement is similar to that employed with sluice gates or valves on large irrigation works, as described in our issues of May 30, 1907, and Jan. 2, 1908. An automatic hydraulic gate valve on a water main at Detroit was described and illustrated in our issue of April 17, 1902. This was on a by-pass at a meter connection for a suburban supply, and was normally closed. It was opened by excess of pressure on the up-stream side when any sudden demand reduced the pressure on the down-stream side.

The stem of each valve is connected to the piston rod of a hydraulic cylinder, and in the outer end of the stem is an eye to allow of attaching a jack in case the hydraulic pressure should fail to operate the valve. The valves are designed to open and close freely with pressure on one or both sides of the gate, and with a water pressure in the cylinder of from 25 to 60 lbs. per sq. in. The cylinders have pressure pipes connecting them with the mains, and the regular city pressure is used to operate them. The cylinders are drained to avoid freezing in cold weather. These hydraulically operated valves are of 36 ins., 42 ins. and 48 ins. diameter, and are located as follows:

Chicago Ave. pumping station; three horizontal 36-in. valves on the three main discharge pipes, just outside the station. These were installed in 1906 and 1907.

14th St. pumping station; one horizontal 48-in. valve on the north pipe leading west from the station in 14th St. This was installed in 1907 (Fig. 1).

Lake View pumping station; two 42-in. valves are on the suction and one (inside the station) on the discharge pipe of the new 25,000,000 gal. pumping engine. These have been installed recently. One 48-in. valve and two 36-in. valves are to be set in the discharge pipes outside of the station.

The 36-in. valves at the Chicago Ave. pumping station can be closed in 1 min. 10 sec., and they close tight and open full. They are set in the basement of the building and have no provision for shutting off the water entirely and draining out the cylinders, which would be necessary in the case of valves set outside the station. The 48-in. valve at the 14th St. pumping station (Fig. 1) is set in a vault under the sidewalk outside the building.

In the case of the valves to be set on the discharge mains at the Lake View pumping station, it is proposed to run the pressure connections inside the station and have the three-way cocks on a switchboard with a plan of the valves above them and each cock numbered to correspond with its valve number. This will make a very convenient arrangement for controlling the discharge system.

In Fig. 2 are shown the details of one of the three 42-in. valves recently installed at the Lake View pumping station. These were built by the Kennedy Valve Mfg. Co., of Elmira, N. Y. The water pressure is 25 lbs. in the case of the light or low pressure valve and 100 lbs. in the case of the heavy valve. The cylinders are 17½ × 48 ins. and 30½ × 48 ins., respectively, and operate under a pressure of 40 lbs. They are lined with bronze. Each gate valve is of the company's double-disk parallel-seat type, as used ordinarily for water-works equipment. The high pressure valve (on the discharge pipe) has a by-pass with 5-in. gate valve.

In opening the valves, the first movement of the stem releases the cams (A), which have inclines in opposite directions on the faces coming into contact with similar inclines on the backs of the disks. Owing to the abrupt pitch of these inclines, the disks at once fall away from any contact with their seats, thereby preventing any dragging against or grinding of the faces of the valve seats or disks in the movement of the valve. In closing the valve, these operations are reversed. The disks (bearing the cams and cam

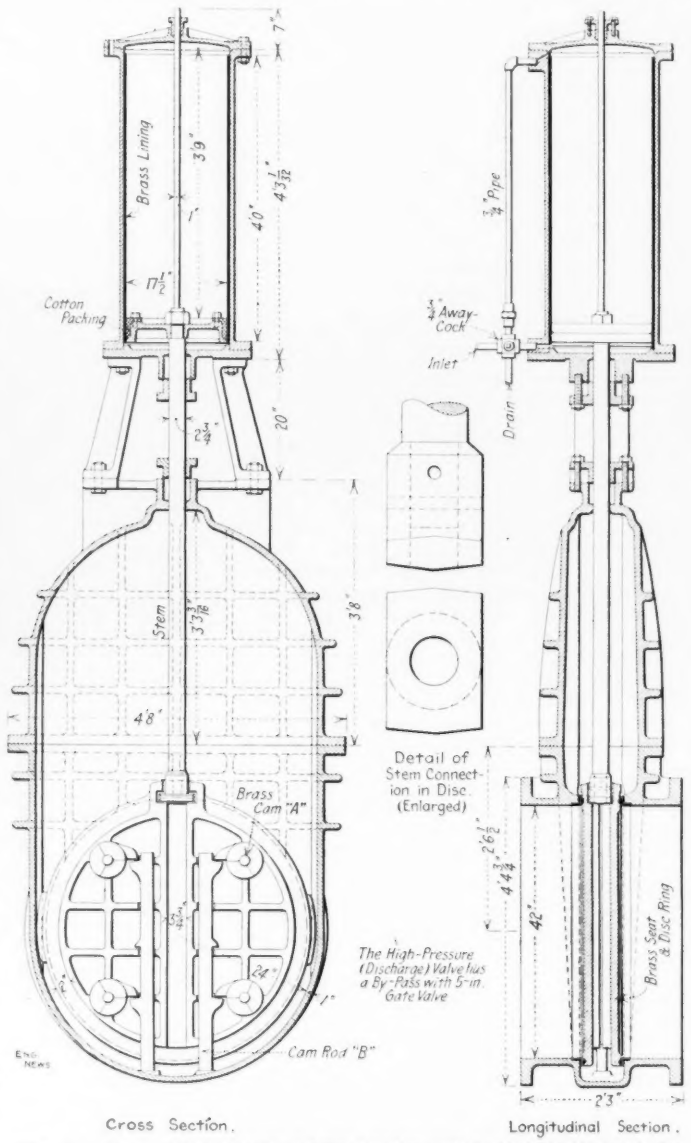


FIG. 2. 42-IN. HYDRAULIC GATE VALVE ON A SUCTION MAIN OF THE LAKE VIEW PUMPING STATION; CHICAGO WATER WORKS.
(Kennedy Valve Mfg. Co., Elmira, N. Y., Makers.)

rods) close until opposite the ports; then the cam rod (B) is brought to a stop by lugs cast on the inside of the body of the valve. This brings into operation the oppositely inclined surfaces of the cams and disks, and the valve is thus closed at once by direct pressure against the faces.

The Use of Asphaltic Flux for Coating Macadam Roads at Palo Alto, Cal.

By J. F. BYXBEE, Jr.*

The town of Palo Alto has been experimenting in a small way on oils, tars, etc., as a coating for macadam roads, but has finally adopted an asphaltic flux as giving the best satisfaction.

This material is the flux generally used here for softening asphalt in the manufacture of asphalt pavements. The specifications are as follows:

The refined liquid asphalt must be a stiff residuum of petroleum oil with an asphalt base. It must be free from water and from light oils volatile at less than 250° F. When 20 grams are heated to a temperature of 300° F. for five consecutive hours in an uncovered cylindrical dish 3½ cm. high by 5½ cm. in diameter, it must not lose more than 5% in weight. It must contain not less than 99% of bitumen soluble in chloroform and must contain no free carbon.

We heat the bitumen to about 200° F. and sprinkle it on the cleaned surface of the macadam through a slotted nozzle about 6 ins. long by ⅛-in. wide. The asphalt must be brushed out even immediately upon striking the surface, for it will not sweep when cool. We find that about 0.3-gal. per sq. yd. is sufficient to make a good surface. The bitumen clings well to the exposed rock on the surface of the macadam, and upon applying clean screenings sufficient to absorb the surplus material, a tough bituminous mat is formed varying in thickness from ¼ to ½-in. This mat protects the rock from wear and greatly reduces the dust nuisance. It sheds water perfectly and resists wear far better than anything else we have tried.

The cost of the bitumen at Palo Alto is approximately 10 cts. per gal. The screenings required for the surface sprinkling amount to about 1 cu. yd. for each 70 sq. yds. of coating.

*City Engineer, Palo Alto, Cal.

The total cost for material and labor in doing this work is approximately as follows:

	Per sq. yd.
Cost of bitumen	$0.035
Cost of heating, spreading and dressing with screening (including cost of screenings)	0.0125
Cost of sweeping street previous to applying coating	0.005
Total	$0.0525

For cleaning the surface of the macadam, we use a revolving horse-drawn sweeper with a stiff wire broom. This very successfully scratches the surface and slightly exposes the coarser rock. The dust and finer particles are finally swept off by hand. A clean, well-compacted and strong dry surface is very essential to the success of the work.

One of the virtues of the coating is its lack of objectionable odors, such as are found on surfaces treated with oils and tars.

Our experiments have not been conducted sufficiently long to estimate the life of the coating, but we presume that to keep the surface in first-class condition it should be lightly redressed each year.

A Machine for Tracing the Profiles of Rail Sections.

Discussions on the quality of rails have been somewhat numerous for the past year or two, and considerable attention has been given to questions of the design, manufacture and wear of rails. With the demand for better rails and the introduction of rails of new sections or made under new specifications, and also with the increasing use of open-hearth rails, there is an increasing necessity for observing and recording the behavior of the rails in service. One of the important observations is in regard to the rate and character of wear of the rail head, and this particular class of observations will give an impetus to the use of special devices for tracing the section of the rail at different periods. Machines or devices of this kind have been invented at different times, but have been used hitherto only to a very limited extent.

One of the newest machines, which is in use on the Great Northern Ry., is shown in Figs. 1 and 2; it is known as the Johnson rail pantograph. It consists essentially of a frame clamped to the rail and carrying a pantograph frame having a pencil which traces on a sheet of paper the path described by a pointer which is moved over the rail head (and in contact with it). In Fig. 1, the feet (A, A) rest on the rail base (the machine being accurately centered) and form the support of the frame. The two hooks (B, B) grip the bottom of the rail head, being drawn tight by means of the screw (C). The pencil is inserted at (D). There are three tracing points (E - 1, E - 2 and E - 3) which trace respectively the form of the top and sides of the head, as shown by the diagram in the corner of Fig. 1. The table (F) rests on top of the rail, accommodating itself automatically to the height of different rails. The holder (G) contains a roll of paper, the free end of which is clamped to the table. After the drawing is completed, the paper is pulled to the right, and torn off against the serrated edge (H). The drawing is made to the natural scale.

Fig. 1 shows the machine ready for use, with the top tracing point (E - 1) resting on the rail

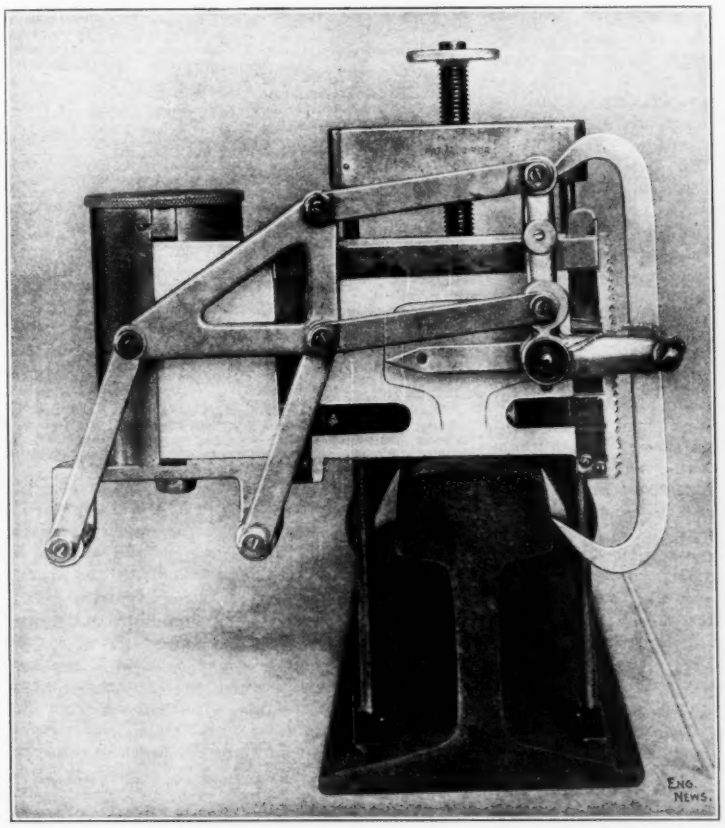


FIG. 1. THE JOHNSON RAIL-PROFILE MEASURING MACHINE.

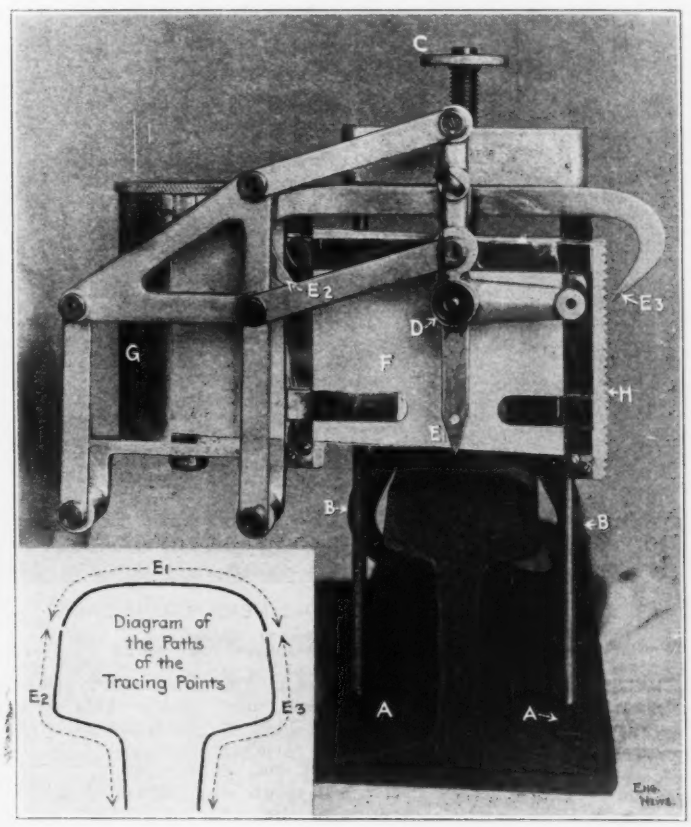


FIG. 2. COMPLETING THE TRACING OF THE RAIL SECTION WITH THE JOHNSON MACHINE.

The Sterling Co., Minneapolis, Minn.; Makers.

.....To.....Div.

Location	Rail	Brand	Rail No.	Heat No.	Date Laid	Date Inspected	No. of Section	Alinement	Ties	Tie Plates	Inclination of Track	Inclination of Rail	Present Height of Rail	Distance C to C	Minimum Present Gage	Total Tonnage Passed since laid	Total Wearing Area	Area Worn	Remarks
St. Paul.																			
E End Br No 1	North	III. St Co.	9010	35819	5/5/08	1/1/09	1	Tan.	Soft	Int. 58			5 15/32"	4'11"	4'8½"				
100' E M.P. No 1	South	IX, 1908	"	35818	"	"	2	"	"	"			"	"	"				

FIG. 3. FORM OF FIELD BOOK FOR RECORDING OBSERVATIONS OF MEASUREMENTS OF RAIL SECTIONS.

head. Fig. 2 shows the tracing point (E-3) completing the drawing of the right hand side of the rail. The machine is readily and quickly attached to and removed from the rail, and it takes but little time to make the drawing. The observations are tabulated in field books ruled as shown in Fig. 3. The machine is built of steel and aluminum, and is tested to an accuracy of 1-5,000-in. It weighs 3½ lbs., or 9¾ lbs., in the traveling case. A clinometer (not shown in the cuts) indicates the inclination of the rail from the vertical.

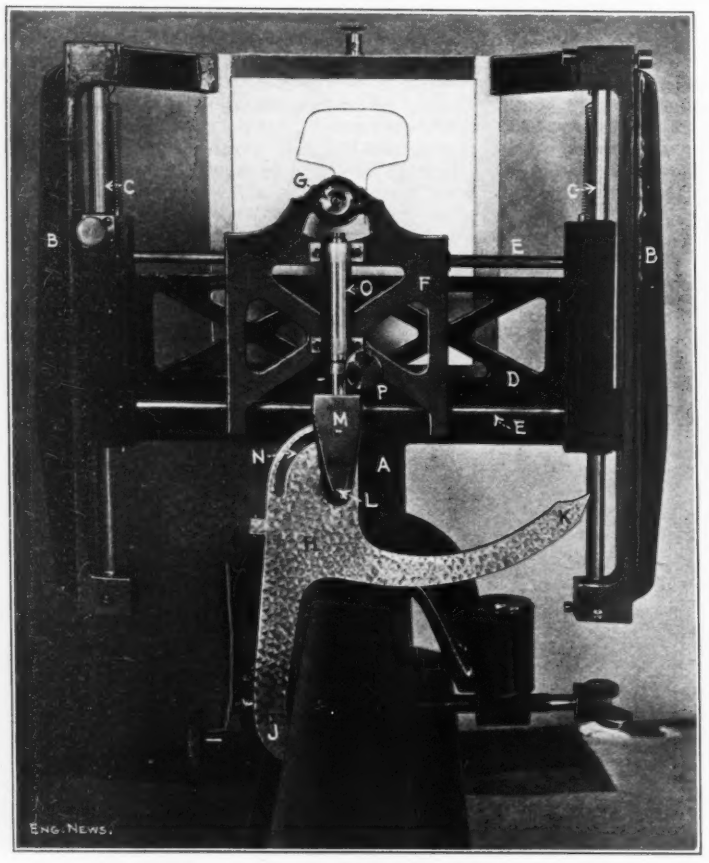


FIG. 4. A GERMAN RAIL PROFILE MEASURING MACHINE.

Sommers & Runge, Berlin, Germany; Makers.
Eugene Dietzgen Co., Chicago and New York; Agents.

This machine was designed originally for Mr. A. H. Hoagland, Chief Engineer of the Great Northern Ry., by Mr. W. P. Whitten, Office Engineer, and Mr. E. E. Johnson, Mechanical Engineer. It is now being manufactured and put on the market by the Sterling Co., 1010 Pioneer Press Building, Minneapolis, Minn.

A German machine for measuring rail profiles is now being introduced in this country, and is in use on four or five railways. It is manufactured by Sommer & Runge, of Berlin, Germany, and is sold in this country by the Eugene Dietzgen Co., of Chicago. The accompanying cut, Fig. 4, is reproduced from a photograph taken for us by Mr. A. J. Neafie, Principal Assistant Engineer of the Delaware, Lackawanna & Western Ry.

The saddle (A) rests upon the rail and is secured to it by thumb-screws, with an arrangement for releasing these screws quickly. The travel of the tracing point is reproduced by the pencil through the movement of two frames sliding at right angles to each other. The stationary frame (B) carries the paper for the drawing and has two vertical rods (C) on which slides the cross frame (D). The weight of the sliding frame is counterbalanced by the two spiral springs. This frame has two horizontal rods (E), on which slides the frame (F). This frame carries the pencil at (G) which is held against the paper by a spring. To the frame is pivoted the tracer (H), which has two tracing points (J) and (K). The tracer can be revolved through an arc of 90° around the horizontal pivot (L), its travel being limited by the stop (M) working in the slot (N). The tracer can be revolved also 180° around the vertical pivot (O).

In operation, the two sliding frames are set at the top and left-hand positions respectively, and the tracer is set in the position shown. The tracing point is then moved upward, following the contour of the rail until it clears the top of the head. The tracer is then revolved 90° around (L), bringing its point (K) upon the rail head. When the surface of the head is traced, the clamping screw (P) is released, and the tracer revolved 180° around its vertical pivot (O), which brings the point (J) in position for tracing the other side of the rail.

The Delaware, Lackawanna & Western Ry. has on different parts of its line rails of Bessemer, open-hearth and manganese steel, made by different makers and under different specifications. Records are taken from time to time, covering the wearing qualities of each different kind of rail. Curves are laid with three or more kinds of rails, which thus carry the same traffic under the same conditions as to degree of curvature, superelevation, ties and ballast. Records are then taken from these rails with the profile machine every two or three months, showing the amount and character of wear that is taking place. This gives very valuable information as to the character and quality of the several rails.

THE MILK INDUSTRY OF CHICAGO is estimated to cost the people about $25,000,000 annually, and to average 962,000 qts. per day. The milk comes from some 12,000 farms located throughout a wide area. On Jan. 1, 1909, an ordinance came into effect, providing that all milk and cream sold in the city or used to produce butter and cheese for sale in the city must be from tuberculin-tested cows, or in default of this that the milk should be pasteurized by methods meeting the approval of the Health Department.

Block Signal Statistics for Railways of the United States.

Statistics of block signals on railways of the United States are reported by the Block Signal & Train Control Board of the Interstate Commerce Commission for the date Jan. 1, 1909, in a bulletin just issued. It gives the information in four tables: Table 1, Mileage of automatic and nonautomatic block signals for the various railways, and percentage of length of railway line; Table 2, Mileage of the different kinds of automatic signals; Table 3, Mileage of the different kinds of nonautomatic signals; Table 4, Mileage of the different practices or methods of working nonautomatic block signals.

BLOCK-SIGNALED LINE.—The total length of block-signaled line in the United States is 59,549 miles, which is about one-third of the mileage of the railways included in the table. Of this 12,191 miles have automatic signals, and 47,358 miles nonautomatic.

Of railways more than 100 mi. long, the following eight have the entire length of their passenger lines block-signaled:

	Miles.
Buffalo, Rochester & Pittsburg	422
Chicago, Burlington & Quincy	8,218
Chicago, Milwaukee & Puget Sound	623
Chicago & Erie (part of Erie Ry.)	249
Lehigh Valley	1,145
Minneapolis, St. Paul & Sault Ste. Marie	1,992
Lake Shore & Michigan Southern	1,446
Michigan Central	1,192

Eight others have 90% or over of their passenger mileage block-signaled:

	Length of passenger lines, miles.	Per cent. block-signaled.
Bessemer & Lake Erie	188	98.8
Chesapeake & Ohio	1,507	98.4
New York Central & Hudson River	2,846	99.2
Pittsburg & Lake Erie	184	93.8
Norfolk & Western	1,921	89.7
Northern Central (part of Pennsylvania system)	440	96.2
Cincinnati, New Orleans & Texas Pacific	336	99.8
Wabash	1,955	93.5

The largest *mileages* of block signals are on the following lines, which comprise all those having more than 1,000 miles of road block-signaled:

	Automatic.	Nonaut.	Total miles of road block-signaled.
Atch., Top. & S. Fe (5377)	79	1,457	1,536
Baltimore & Ohio (3083)	173	888	1,061
Chesapeake & Ohio (1507)	11	1,472	1,483
Chicago & Northw'st'n (7707)	606	2,516	3,122
Chic., Bur. & Quincy (8218)	28	8,675	8,703*
Chic., Mil. & St. Paul (6550)	49	3,874	3,923
Erie (1745)	76	1,262	1,338
Lake Shore & Mich. So. (1446)	518	993	1,511*
Lehigh Valley (1145)	481	742	1,223*
Michigan Central (1192)	272	920	1,192
Minn., St. P. & S. Ste. Marie (1992)		1,992	1,992
N. Y. Central & H. R. (2846)	146	2,687	2,833
Norfolk & Western (1921)	67	1,657	1,724
Northern Pacific (4732)	19	1,279	1,298
Pennsylvania (3296)	245	2,212	2,457
Pittsburg, Cincinnati, Chicago & St. Louis (1417)	9	1,094	1,103
Southern (6002)	3	1,599	1,602
Southern Pacific (5966)	1,898	95	1,993
Union Pacific (3134)	1,222	11	1,233
Wabash (1955)	7	1,821	1,828

*Note: For the C., B. & Q., L. S. & M. S., and L. V. lines, the signal mileage given includes mileage over which passenger trains are not regularly operated, or where only one engine is in service, which mileage is not included in the total miles of passenger line.

It appears from the table that the Burlington, the St. Paul and the Northwestern are far in the lead for total mileage block-signaled, while the Southern Pacific and Union Pacific are far in the lead in automatic signals, with the Northwestern next in order.

KINDS OF AUTOMATIC.—As to kinds of automatic signals in use: The Southern Pacific and Union Pacific employ electric-motor semaphores almost exclusively, while the Northwestern is equipped almost wholly with inclosed disk signals. The totals for all the roads listed are as follows, expressed as before in miles of road:

Exposed disk	392
Inclosed disk	1,781
Electro-pneumatic semaphore	411
Electric-motor semaphore	8,665
Electro-gas semaphore	925
Total: Miles of road	12,174
equals: Miles of track	20,591
and has: Block sections	18,605

About three-fourths of this mileage is arranged on the Normal Clear plan.

KINDS OF MANUAL.—The different types of nonautomatic or manual blocking have the following mileages:

	Miles road.
Morse telegraph	38,074
Telephone	5,644
Electric bells	859
Controlled manual without track circuit	1,557
Cont. manual with track circuit at stations	408
Cont. manual with continuous track circuit	572
Electric train staff	261
Total: Miles of road	47,378
equals: Miles of track	57,803
and has: Block signal stations	9,439

The chief road using a continuous track circuit with the controlled manual system is the New York Central, with 438 miles of road.

The principal contributors to the telephone block system are: Atchison, with 1,419 miles; Northwestern, with 531 miles; Burlington, with 1,504 miles; Puget Sound, with 623 miles; Omaha, with 386 miles; Northern Pacific, with 232 miles; Pennsylvania, with 187 miles; and Frisco, with 384 miles.

The electric train-staff system is represented principally by the Atchison, with 38 miles, and the Southern Pacific, with 94 miles.

PERMISSIVE BLOCKING.—The table of methods used in working nonautomatic signals shows that "permissive" signaling is permitted on 37,000 miles of line, and is forbidden on 10,500 miles; that is, only 22% of the mileage is worked under strict block rules.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Candler Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

GEORGE H. FROST, President
CHARLES WHITING BAKER, Vice-President
HARWOOD FROST, Secretary
FRANCIS W. FROST, Treasurer

ALFRED E. KORNFELD, Manager
EDWIN HUNT FROST, Ass't Manager

CHARLES WHITING BAKER, M. N. BAKER, E. E. R. TRATMAN, F. E. SCHMITT, } Editors

SUBSCRIPTIONS

United States and Possessions, Mexico and Cuba, One Year, $5.00.
Canada, $7.00 a Year.
Foreign Countries, Regular (Thick Paper) Edition, One Year, $9.00. (£1-18-0.), 45 Francs or 37 Marks.
Foreign Countries, Thin Paper Edition (Construction News Supplement Omitted), $7.00. 29 Shillings, 35 Francs or 29 Marks. Remit directly to our office.
Pay no money to canvassers for subscriptions.
Remit by Post-Office or Express Money Order, Draft on New York or London, or by Registered Letter.
Notice of change of address should reach us one week in advance of removal. The old as well as the new address should be sent.
Subscriptions cannot be dated to commence with past issues. All subscriptions commence with current issue and back numbers can be supplied only by special order.
Receipts for Subscriptions will not be sent unless requested, the changing of the expiration number being considered sufficient. The number on the address label indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year. 52-9 means the 52d week or December 26, 1909.

ADVERTISING

"Contract": Rates furnished on application.
"For Sale": $1.50 per inch.
"Proposal": $2.40 per inch.
"Want": See "Want" Pages.

Copy for regular, or "Contract," Advertisements should be received at least ten days before publication; "For Sale" and "Situations Wanted" Advertisements by Monday, and "Proposal" and "Situations Open" Advertisements by 9 A. M. Wednesday.

Entered at the New York Post-Office as Second-Class Matter

If a photograph is to be reproduced in any publication, always try to secure a brown or "solio" print from the negative rather than the common black and white or "velox" print. The "velox" paper is now most commonly used for making photographic prints, particularly for amateur work, on account of the ease in printing and also because of the artistic effect produced by the blending of the outlines into the mass. But this very indistinctness of outline which gives the velox photograph an artistic effect makes it unsuitable for reproduction in a cut. The half-tone process of photographing through a screen so reduces the intensity of the print that contrast of light and shade and sharp definition of outline in the original are most necessary. Such contrast and definition are much more frequently found in the solio brown print. In cases where we have had prints by both processes from the same negative, much detail could be distinguished on the brown print which was a mere shadowed mass on the black-and-white, a difference noticeable on the original and emphasized on the reproduction.

Occasionally, there are black-and-white prints, especially those known as "platino" prints, which show few of the faults of the ordinary velox and are better for reproduction than the average solio, but these are expensive and difficult to make and are rarely used for reproducing work. Experience has shown that with the average photograph print not the work of experts or the result of a costly process of printing, the contributor will stand a much better chance of having his article well illustrated if he furnishes brown instead of black-and-white prints.

The up-hill work of the North Carolina State Board of Health and its secretaries was commented upon editorially in our issue of April 15. We are pleased to be able to state that the recent session of the North Carolina Legislature made a number of important amendments to state health laws. Among these was an increase of the appropriation for the general work of the board, from the previous very low figure of $2,000 to $6,000. Even more important, from the viewpoint of the future efficiency of the Board, is the increase in the salary of the secretary from the former ridiculous figure of $1,000 to $3,000 a year. This increase is coupled with the provision that the secretary hereafter shall devote his whole time to the work. Appropriations for special work of the Board were also increased, notably the allowances for combating tuberculosis. Sections of the state health laws designed to protect water-supplies were strengthened in a number of particulars. A condensation of all the health laws of the state was given in the bulletin of the Board for March, 1909. We learn from another source that Dr. R. H. Lewis, who for a number of years past has carried on the work of the Board under great discouragement, has felt it necessary to resign in view of the provision of the new legislation to the effect that the secretary must give all his time to the work. This, however, we understand he gladly does, in view of the good that will come to the state under the new plan. Dr. W. S. Rankin, Dean of the Wake Forest College of Medicine, has been chosen to succeed Dr. Lewis. Dr. Rankin specialized in bacteriology and pathology at Johns Hopkins University after taking the medical course at the University of Maryland, and in 1901 took the chair of bacteriology and pathology at the institution of which he became dean four years later. It is to be hoped that a number of other states in the South and West will follow the example of North Carolina in making more liberal appropriations for their state health work and in strengthening their sanitary legislation, particularly that relating to water-supply, sewage disposal and stream pollution.

If a cat has nine lives, how many times will it be necessary to kill the effort to turn the Philadelphia water-works over to private ownership and profit? There seems to be something about Philadelphia and its municipal government which encourages raids upon the public treasury and the pockets of its citizens which would never be dreamed of in connection with any other city. Who ever hears of a proposition to turn the water-works of Boston or Chicago or St. Louis or Minneapolis, or any other important American city over to a company? The latest designs on the Philadelphia water-works appear to emanate from Providence, R. I. Perhaps they originated in the fertile brain of some newspaper reporter who was hard pressed for "copy"; but they so much resemble earlier stories of the sort that some credence may be given them. The city officials of Philadelphia disclaim all knowledge of the proposition, and altogether this particular plan to lease the water-works of that city looks more like a promoter's gold-brick scheme than anything else. According to a press despatch from Providence, published in the Philadelphia "North American" of May 6, one N. Goodwin Green, of Boston, "has undertaken to obtain a 70-year lease of the public water plant of the city of Philadelphia," and very generously offers all comers $6 in securities for every $1 invested in the enterprise. We look to see the scheme come to naught, as have so many others which, with far more promise of success, have preceded it. The day when a lease of the water-works of a large city could be made to a private company has passed, never to come again. We say this notwithstanding the notorious incidents of the last few years, connected with the lease of the Philadelphia gas-works and the later proposal to extend the lease far into the future.

The disaster at Peoria, Ill., where three of the long arches of the City Bridge collapsed into the Illinois River, is the largest recorded failure of a reinforced-concrete bridge, and from that fact is certain to be used by the anti-concrete interests as an argument against such construction. However, the reports of the accident and the history of the bridge, which we give on another page of this issue, show that the collapse cannot be ascribed to the form of the construction, but was due to the old fault of "building upon the sand." Obviously, the material in a bridge upon piers insecurely founded on a shifting bottom had nothing to do with the instability of those piers, though the arch form increased the necessity for rigid foundations and rendered the driving of battered piles more necessary than if a vertically bearing bridge had been built.

Apparently the Peoria collapse is the result of a combination or sequence of events, any and all of which, in the light of present knowledge, might have been guarded against if ordinary precaution had prevailed. The number of original borings were too few, and with these borings off the line of the bridge showing so insecure a bottom, new borings on the line of the bridge should have been taken. With the information at hand, the question as to the practicability of a pile foundation is one that cannot be settled offhand; but it is certain that a pile foundation once decided on as possible, it was absolutely incumbent on the superintending engineer to see that the full measure of piles be driven to their refusal on rock bottom, and that batter piles be placed to guard against horizontal movement. Although the evidence is not complete, this latter seems not to have been done. Lastly, the removal of the sheet piling from around the pier destroyed the first line of defense against scour and left the piers to depend solely upon the column-bearing power of piles which probably did not even reach a solid base.

Until the matter is more fully investigated, the responsibility for the failure cannot be placed. Probably this question will be finally decided by the courts. But from an engineering standpoint the causes seem to be insufficient data, careless execution and too great trust on the stability of pile foundations in soft ground. It adds another example to the engineering principle that the safety of the structure is primarily the safety of its foundation.

The recent failure of the City Bridge at Peoria, Ill., is said, with what truth we know not, to be a fitting monument to the character of three successive municipal administrations. Directly after the failure, a new city administration came into power. The Peoria "Journal" says $225,000 has already gone into the river and that $50,000 may go after it before the bridge wreckage can be removed. To bring such doings to a stop, and to secure efficient municipal government as well, the "Journal" advocates the substitution of a business for a political form of city government. Its reasoning is so interesting that we reprint the following extracts from its columns for May 2, 1909:

> The City of Galveston, Tex., was the first city in all this broad land to adopt the commission plan of municipal government. It was driven to it by necessity, as that city was almost wiped off the face of the earth by a terrific storm and tidal wave. * * * * The people of Galveston realized that under ordinary conditions and through means of party politics it would take a quarter of a century and untold millions of money to rebuild the devastated city. So they made up their minds to abandon political government, and in its place to institute business government. They resolved to trust their future to business men rather than politicians.
>
> So it was that through the throes of distress arising from an unparalleled calamity the commission plan of city government was born in the city of Galveston, Tex. In little more than the time Peoria has been trying to build a bridge the city of Galveston was rebuilt.
>
> Is there not a hint in this for the city of Peoria? Is there not a moral to be drawn from the fact that three successive administrations have tried in vain to give the city of Peoria a bridge, and that after spending hundreds of thousands of dollars the latter end of the city is worse than the beginning? * * * *
>
> From the experience of the past there is to be drawn no hope for the future. That is, under the present plan of conducting the business of this city. The whole system is wrong. Private enterprise, business energy, built a bridge in a year for a railroad company that is to-day being generously offered to the city to use until the politicians can build another bridge or further impoverish the taxpayers of Peoria. Under the commission plan of city government there would have been none of the mistakes of the [three administrations just past].

In a feebler way Peoria is in the situation of Galveston after the cyclone passed and the troubled waters returned to the sea. The difference is in the magnitude of the disaster. But what brought out destroyed Galveston after wind and wave had worked their will, would bring Peoria out from its present emergency, and that is the exercise of common sense and business tact. Let the city cease to be ruled by politicians, and let business judgment supplant party strife. * * * *

People may ask what caused the disaster? Answer, dirty politics.

We have no knowledge of either the politics or the form of government of the city of Peoria. However bad either may be, we believe it would be possible to do much political cleansing without making any change in the form of the city government. At the same time, it is doubtless true of Peoria, as of hundreds of other cities, that it is so bound by the traditions and practices of partisan politics and so deep in many a time-worn and muddy municipal rut that nothing short of the inspiration and promise of an entire change in the form of its government would induce its most able and honest men to assume responsibility for its municipal administration. But it is not always possible to change the form of municipal government in short order, and if a change cannot be immediately effected at Peoria we suggest that the administration which has just come into office has a splendid opportunity to show that after all it is the kind of men rather than the kind of charter that is most essential to good city government. The municipal public and press has its opportunity and duty, also, for no body of men, working under no matter how poor a charter, can withstand the demands of enlightened, determined public opinion, well voiced by an able, upright press.

One of the greatest evils of congestion of population due to the growth of cities large and small is that, unless great care is taken to prevent it, children will be virtually deprived of what should be one of the most precious rights of a child—the right to play out of doors. Although there has been a strong movement for playgrounds in many cities of the United States of late, few of them have as yet provided anything like the number and area of these that are needed. Consequently, thousands of children must either play on the public streets or else not play out of doors at all. As can readily be seen, this is not only dangerous to children, but it also greatly aggravates the impediments to vehicular traffic, which are already so great in many sections of our larger cities. In order to give the children a better and safer opportunity for out-door play, and at the same time to facilitate the movement of vehicular traffic, a proposition is now under consideration in New York City to devote certain streets to the exclusive use of children between the hours of 3 and 6 p. m. each day. During this period the vehicles would be forced onto the adjoining streets, with the expectancy that the greater rapidity of movement possible through the relative absence of children from those streets would more than make up for the diversion of the traffic, while at any rate the children would have a chance for out-door exercise.

The need for some such plan in New York City becomes apparent when it is stated that living in each of a number of East Side blocks there are from 250 to 1,000 children. The high record seems to be held by the block in Ludlow St., between Houston and Rivington, in which there are 1,075 children, nearly 500 of whom are below school age. The need of doing something to regulate either children or traffic in New York streets is also indicated by the statement that since Jan. 1 of the present year about 20 children who were playing in the streets have been killed, and over 40 have met with serious accidents; this, too, before warm weather set in. The scheme outlined above for New York City has been worked out, we understand, by the Parks and Playgrounds Association, and a trial of it is reported to have been approved by Commissioner of Police Bingham.

The Utilization of Low-Temperature Heat to Produce Power.

We present to our readers in this issue two articles describing the work of inventors in the development of power from the sun's heat. While the work of neither of these inventors has reached the stage of actual commercial development, each of them has done enough in the way of experiment and actual construction to fully justify laying their results before the engineering public. The work of the first of these inventors, Mr. Shuman, was brought to our attention nearly two years ago and has received considerable publicity in the newspapers and elsewhere. The work of the other inventor, Mr. Willsie, has never before been put on record in engineering literature, and is deserving of particular notice, as his experiments have been carried considerably further than Mr. Shuman's. It may be stated here that Mr. Willsie is a graduate in mechanical engineering of the University of Wisconsin and has conducted his work in the development of his invention on an engineering basis. Mr. Shuman is an engineer of many years experience and has associated with himself a number of other engineers in carrying out his work.

It is of interest to see that both these inventors, starting in about where Ericsson and similar unpractical inventors abandoned the problem in disgust, have worked along lines almost identical. It does not require any very deep study of the problem to lead to the conclusion that if commercial success is attained at all in sun-power development, it must be along the paths which these two inventors have followed. In both cases the apparatus resolves itself into a heater by which water (or possibly some other fluid) is heated by exposure to the sun's rays. The heated water is then made use of to develop power. In Mr. Willsie's case, he adopts the well-known sulphur dioxide engine of Professor Josse, of Berlin, although, of course, any other working fluid volatile at low temperatures might be used. Mr. Shuman originally proposed this plan, but later abandoned it in favor of the use of the heated water in a low-pressure turbine. So far as we are aware, however, he has not yet put this idea into practice.

Both inventors solve the problem of continuous operation by storing the heated water in large tanks. The details of the hot-bed, or apparatus in which the water is exposed to the sun's rays have been worked over with great ingenuity by both inventors. It is likely that upon the details of the arrangement adopted for this part of the apparatus, the practical success of the sun-power plant will largely depend. It will be manifest, we think, to any one who gives study to the problem, that the field of sun-power development will be limited almost, if not quite wholly, to those arid regions where sunshine may be counted on during almost every day of the year. The reliability of sunshine will be even more important than the temperature which the sun's rays attain.

Quite as interesting, it seems to us, as the fact that power can be actually developed directly from the sun's heat, is the fact that these new inventions afford an example of the utilization of low-grade heat for the production of power. At present, all heat engines in commercial use depend for their source of heat upon the combustion of fuel, and have high temperatures therefore available. In the steam engine the temperatures in the boiler furnace range from 2,000° to 3,000°, or higher. This high temperature in the furnace is used to impart heat to water in a closed vessel or boiler, in which the water is raised to a temperature of perhaps 365°, corresponding to a steam pressure of 150 lbs. The steam at this pressure may be used in a non-condensing engine, and if exhausted at 212° will give a temperature drop of 153°. If a higher boiler pressure, say 200 lbs., is used, we have an initial temperature of 387°; and if a reasonably high vacuum is reached in the condenser, the final temperature may be as low as 126°, giving 261° total drop in temperature. Boilers of low pressure, on the other hand, working at say 70 lbs. pressure and exhausting into the atmosphere with some back pressure, may have a temperature drop of 90° or less. In the internal combustion type of engines, the temperatures, both initial and terminal, are very much higher; and part of the high efficiency of the internal combustion engine is due to its greater temperature range.

Engineers who are familiar with thermodynamics clearly understand that the utilization of heat to develop power in any type of heat engine depends upon the drop in temperature. For the benefit of those of our readers to whom this subject may not be so familiar, however, we venture to present a somewhat elementary explanation of this subject.

It may be easily understood by comparing a drop in temperature to the drop of water over a precipice. Every one understands that a natural waterfall is a source from which power may be developed, and the total power available will be the product of the height of the fall by the quantity of water. The same thing holds in the case of power developed by a fall of temperature. A drop of a certain number of degrees will make available from a given quantity of working fluid a certain amount of power. Twice the drop would make available twice as much, or half the drop half as much.

Every one understands, also, that by adapting the water-wheels and other apparatus to the fall, either a high head of water or a low head may be utilized. It does not seem to be so clearly understood, however, that the *possibility* exists with a heat drop as with a water drop, of utilizing a low fall.

All commercial work in the utilization of heat for the development of power thus far has been done with the high falls solely, and one of the reasons is that heating surface in boilers and condensers is expensive. The rate of heat flow through a square foot of heating surface depends on the difference of temperature between the two sides. In order to bring steam boilers within practical limits of size and cost we have to use the high temperatures generated by combustion.

But in all steam boilers we are dealing with heat transmission from a hot gas to a liquid. If the heat transmission were from a hot liquid on one side of the plate to a cooler liquid on the other side, many times as much heat would be transmitted with a given drop in temperature. With a liquid on one side of the plate and a condensible vapor on the other, as in a steam condenser, for example, the rate of heat transmission is also many times greater than in heating water by furnace gases.

The commercial utilization of low grade heat for power, therefore, turns largely upon the possibility of making low cost heat transmitting or heat collecting surfaces. In the sun-power plants described in this issue, this has been done by discarding the plan of heating water under pressure and heating it instead in shallow tanks protected by only a glass cover.

In the actual production of power from this hot water in the sun-power plant, the temperature drop is quite considerable. For example, the hot water may be used at a temperature of say 200° and discharged at perhaps 100°. Thus the temperature drop will be as great as in some steam engines.

It is interesting, however, to canvass the possibility of producing power with a much smaller drop in temperature. Suppose a volatile fluid engine could be operated with a drop of only 20°. If that were possible, it would then be feasible to utilize some of the natural sources of heat or of cold for the production of power.

It seems strange at first sight to speak of the utilization of cold to produce power; but by drawing a parallel with the waterfall the possibility may be easily understood. A source of cold, such as an ice-cold spring for instance, is exactly like a waterfall drawing its supply from a lake of uniform level and discharging into a narrow gorge. A source of heat, such as a hot spring or geyser, on the other hand, is like a waterfall emptying into a large lake. The deep gorge on the one hand and the ice-cold spring on the other are in neither case a *source* of power.

They each make possible the development of power from the heat or the water lying at a higher level.

Many years ago an inventor proposed to develop power from the intense cold of the Arctic region by a "Zeromotor." The theoretical possibility of such an achievement rests on the difference in temperature between the Arctic seas and the average temperature of the air. A similar theoretical possibility exists in the tropical regions where the ocean maintains a uniform temperature of between 72° and 78°, while the air ranges many degrees higher. The flow from natural hot springs and the discharge from deep underground mine workings offer the possibility of utilizing the internal heat of the earth for power production.

We call attention to these things merely as *possibilities*. Their development for commercial use does not seem probable, at least for a long time to come. It is worth while, however, for engineers to understand something of the possibilities and limitations in this well-nigh unexplored field, for in the future development of our heat engines, more and more work is likely to be done in the utilization of heat of lower temperatures. Examples of this are already at hand in air heaters for waste furnace gases and in projects for utilizing the heat from gas engine jacket water.

Sooner or later, too, we may expect that some unprincipled inventor will take advantage of the thermodynamic possibilities in low grade heat to float stock in a swindling enterprise with the aid of a pseudo-scientific demonstration and reap some such harvest as was reaped by the liquid air swindlers of a decade ago. One can imagine how the credulous would gape with astonishment to see power developed, even in trifling amounts, by utilizing the water of a cold spring and would hasten to invest in the new "Zeromotor." We trust that before any such charlatan use is made of this thermodynamic possibility, some engineer or capitalist will come forward and test the possibilities of development along these lines and definitely establish the commercial limitations.

LETTERS TO THE EDITOR.

Reinforced Concrete for Boiler-House Floors.

Sir: I would like to hear from any steam power-plant engineers who have had occasion to note the durability of steel in the firing floor of a boiler house. Is it wise or unwise to cover all steel sections in the firing floor around the stoker pits or ash pits with concrete? And how much (if any) would the covering prolong the safe service of the steel?

In the particular case in question there are fine-coal hoppers and ash hoppers, of reinforced concrete, below the stokers. The point arose as to the durability of the reinforcing steel, also the durability of the structural sections encased in concrete.

The protective quality of concrete against corrosion under ordinary conditions is well known. But I would like to hear the experience of others for this particular condition, with the extremes of heat and cold, with the quenching water for cinders, the acids and gases.

Yours truly,

W. A. Hoyt, C. E.

1218 Chamber of Commerce Bldg., Chicago, April 22, 1909.

Further History of the Combination Retaining Wall and Quay at Chantenay, France.

Sir: In Engineering News, April 22, 1909, p. 433, you give a description of a cantilever pier at Chantenay, France. It might be of interest to your readers to have the information amplified somewhat, although the writer has been unable to find anything describing the reinforcement used.

The structure in question and a similar one at Grands Moulins, at Nantes, are both mentioned by Mr. M. G. Liebeaux in his paper in "La Revue Generale des Chemins de Fer," Dec., 1901, and they were then several years old, so the "novelty" is not so very striking after all. I beg to quote from Mr. Liebeaux's paper:

The erection of this second cantilever pier (at Chantenay) and of the adjacent quay has caused certain events and disappointments which must be noted on account of the publicity and discussions created.

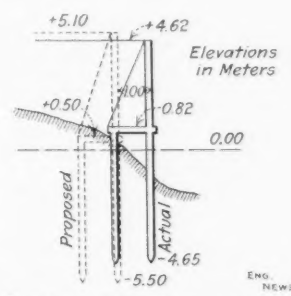
The entire length of the structure is 136 m. (447 ft.), of which the cantilever occupies 60 m. (197 ft.) in the middle, the adjacent retaining walls being 45 m. (148 ft.) and 31 m. (102 ft.) long to the right and left, respectively. The portion EF of the wall (see accompanying figure) curved out with a deflection of 0.23 m. (9 ins.). Between A and B a portion of the wall overturned, causing a large crack to the right of the first buttress.

At this time the cantilever portion had been in use some time after having passed the test load specified without signs of trouble. As a matter of precaution the unloading of coal was discontinued and no use was made of the pier until a much later time, when the entire structure had been completed and the stability of the work had been proved by new tests.

After removal of the embankment it was found that several ties had slipped, but no more trouble was experienced after the ties were reinforced. It is therefore believed that the ties were entirely too light.

It is also stated that the pier was submitted to undue impact on account of the unfortunate location of a dead man used to stop the loaded coal wagons. The severe shocks imparted to the structure were too much for the already inefficient ties.

In the portion A B the piles were reduced 0.5 m. (1.6 ft.) in length and in addition moved 1 m. (3.3 ft.) further out in the river in the belief that the space above might thus be increased without trouble. The bottom slopes rapidly away from the shore, and the piles be-



Section X-Y showing Proposed and Actual Construction.

Reinforced-Concrete Retaining Wall and Quay at Chantenay, France.

came too short by these alterations. The structure then failed under the load.

The same structure is also shown in "Berger et Guillerme: Ciment arme," 1902, p. 426, under the general head line "Systeme Hennebique". No details of the reinforcement are given, but the plans show a row of sheet piling of reinforced concrete under the toe of the base. It is said to be one of the first applications of reinforced concrete sheet piling. The piles were 6 m. (19.7 ft.) long and were driven with a hammer weighing 1,320 lbs., the drop was 1.89 m. (6.2 ft.).

The enclosed sketch shows some of the details referred to in the paper by Mr. Liebeaux, taken from the "Revue Generale."

Yours truly,

Alexis Saurbrey.

709 New England Bldg., Cleveland, O., April 24, 1909.

Standard Methods for the Bacterial Examination of Water.

Sir: I note in your issue of April 22, 1909, some questions as to the significance of bacterial counts obtained by different operators at filtration plants, particularly on account of incubation of the samples for 48 or 72-hour periods. The writer has for three years made frequent examinations of different filter plants in Ohio, and has obtained considerable information as regards the efficiency of the plants as determined both by the operator and by himself. The results obtained frequently indicate variations in bacterial counts from 50 to 100%, due to different procedures.

At a recent examination of a filter plant evidence was obtained as to the significance in bacterial counts obtained using gelatine and agar media on the same samples and incubated both for 48 and 72 hours. The following points were noted as a result of this test:

(1) On the raw water, a two-day count with gelatine was comparable with a three-day count on agar.

(2) On the raw water, a two-day count with agar gave considerably less numbers of bacteria than a two-day count with gelatine.

(3) On the applied and filtered waters, which contained small numbers of bacteria, the variations in bacterial count caused by different periods of incubation was much greater than with the raw water.

(4) On the applied and filtered waters, a two-day count with gelatine was comparable to a two-day count with agar.

(5) On the applied and filtered waters, a three-day count with agar gave very much higher counts than a two-day count with gelatine or agar.

Evidence indicates the desirability of further experimental work with reference to the proper period of incubation to determine the bacterial efficiency of a filter plant. The difference of 48 and 72-hour periods of incubation is much more marked in the cold weather than in the summer, a fact which is not taken into account in the report of the Committee on Standard Methods and for this reason the difference in efficiencies of filtration plants using different periods of incubation is much more marked in the winter than in the summer.

The writer has frequently found the variations in bacterial counts obtained by 48 and 72-hour incubations so great that it is considered desirable to report counts on both periods, because, while 48-hour incubation is recommended in the report of the Committee on Standard Methods of Water Analysis, it is believed that such counts do not represent the results sought in making bacterial tests of a filter plant.

The report of the Committee of the American Public Health Association on Standard Methods of Water Analysis was published in May, 1905. Experiences since that time show the desirability of revising and enlarging the report, which contains information now known to be incomplete.

Yours very truly,

Philip Burgess,
Assistant Engineer,
Ohio State Board of Health.

Columbus, Ohio, April 23, 1909

Cost of Operating Stone-Crushing Plants.

Sir: In your issue of April 15, page 404 (third column), in the estimate of cost of quarrying and crushing stone for ballast at a quarry plant on the D., L. & W. Ry., I notice this interesting statement as to cost of plant for this work: "plus interest at 5% on the net investment of the quarry and crusher plant."

To one not familiar with wear and tear of crusher plants this might seem reasonable, although any rough machinery as unprotected as a crusher plant would deteriorate more than 5%. The wear and tear at a crusher plant is necessarily greater than on almost any other machinery, and constant expense is necessary to keep the plant in condition. If not kept in the best condition it will not do efficient work.

The rate of "5% interest" allows nothing for wear and tear, and is therefore based on the assumption that the value of this plant will remain stationary for an indefinite period. Quite the contrary is the case. The probabilities all are that within a few years the demand at this particular point will become irregular or cease altogether, when the plant will be worth nothing except for old machinery and certainly not more than 10% of its original cost.

I do not make an estimate of what this charge for wear and tear should be, because it depends almost entirely upon circumstances, but in most cases if the cost of the crusher plant is not realized in profits within four or five years the chances are decidedly that the first cost never will be realized. This is a point that is not always properly understood by many who start into the crushed stone business. It is a business that can be made to look much better on paper than in reality.

C. G. Smith, Jr.,
Vice-Pres., Columbia Granite & Dredging Co.

Washington, D. C., April 17, 1909.

[The figures referred to were quoted (as stated in the article) from a report made by Mr. Lincoln Bush, M. Am. Soc. C. E., while he was Chief Engineer of the Delaware, Lackawanna & Western Ry. We referred the enquiry to Mr. Bush, and his reply is given below.—Ed.]

Sir: I have noted with interest what your correspondent has said in regard to my report to the American Railway Engineering and Maintenance of Way Association, including in cost of ballast an interest charge of 5% on the investment, and also what he has said regarding the extraordinary expense for repairs connected with the operation of a crusher plant and the value of such plant after a few years of operation.

In the article in Engineering News of April 15, you did not give my full and complete report to the association, and I give herewith the second paragraph of my report in full, which will give your correspondent some details of the actual cost of this plant to the D., L. & W. Ry. Co.

Early in 1905, the D., L. & W. Ry. Co. bought near Boonton, N. J., a granite quarry and crusher plant, together with other equipment in the way of cars, machinery, etc., that were utilized by a contractor in connection with the construction of a large masonry dam for a reservoir. This work having been completed by the contractor, the railway company acquired about three miles of railway running from its main line to the quarry plant, together with about 56 acres of ground, tracks at crusher plant, etc. In adapting this plant to its use, and rearranging the tracks and crusher layout to meet its requirements, it expended at the outstart $21,904, and sold from the contractor's outfit certain equipment, which netted $18,159, making the net cost of the quarry and plant $26,245.

It will be evident from these figures that the plant was secured at an extremely low figure, the original cost to the company of the quarry, three miles of track, crusher plant, and a lot of contractors' equipment being $22,500. You will note that in my report I stated that the company sold from the contractors' equipment acquired, plant that netted $18,159, and with the changes made at the

plant by the railway company the total cost of the quarry, tracks, and plant complete, ready to start operations, amounted to $26,245.

Two years ago I built a crusher plant of practically the same capacity in which the plant, exclusive of the quarry or any tracks, cost $48,000.

Mention is made by your correspondent of the large repair cost to a crusher plant, and I would suggest that he secure a copy of the Maintenance of Way Association's report in which full details of how my costs were made up will be found.

The table shown in the report covering cost of output per yard, included in the cost a total of $12,538 for supplies and repairs at the plant. The total cost of labor, supplies, and repairs for the period covered by my report amounted to $63,909 and covered an output of 108,155 yds. of ballast for the 14 months, from May, 1905, to August, 1906, inclusive.

My report shows a total cost for the above period of 55.5 cts. per yd., and it will be noted by the figures I have quoted that the supplies and repairs for this period made up a total of 20% of the total cost of labor, supplies and repair materials.

I purposely gave in my report to the Maintenance of Way Association the detailed cost of the purchase, assuming that any one going into the question of installing a crusher plant would take into consideration the low cost of the plant acquired by the D., L. & W. Ry. Co.

From May, 1905, to Jan. 1, 1909, the output of the Boonton plant was 297,556 yds. of ballast.

The best figure at which the railway company has been purchasing stone of as good quality in New Jersey for ballast is 81 cts. per cu. yd. on cars, D., L. & W. Ry. The total cost per yard as covered by my report was 55.5 cts., showing a saving of 25.5 cts. per yd. This, multiplied by the total output up to Jan. 1, 1909, shows a saving of $75,877. This, it will be noted, is practically three times the cost to the D., L. & W. Ry. Co. of this plant, including land, tracks, etc., ready to start operations.

Your correspondent's comment that in a few years' time the plant and machinery could not be disposed of for more than 10% of its original cost, may be true as a general statement; but it needs qualifications and does not have an application in this particular case.

Yours truly, L. Bush,
Consulting Engineer.

1 Madison Ave., New York, N. Y., April 23, 1909.

Should Steel for Concrete Reinforcement Be Painted?

Sir: Referring to an editorial in your issue of March 25, p. 323, where you criticise a portion of the proceedings of the Fifth Annual Convention of the Maintenance-of-Way Master Painters, in regard to a paper read at that convention, entitled "Should Iron or Steel Embedded in Concrete Be Painted, and If So, How," I must take issue with some of the statements that you make in this editorial, as I think that they are too sweeping in their nature.

I have absolutely no interest with the paint concern whose representative read the paper, but at the same time, I consider that the majority of the statements made by him are correct, and the extract from his paper which you quote is rather misleading, unless the whole paper is read in connection with it.

There is no question but what cement will adhere better to clean steel than it will to either oiled or painted steel, as shown by the following extract of a report on the subject of tests of adhesion between concrete and steel.

These tests were made for the Rapid Transit Railroad Commission of New York City and are reported by Mr. Sverre Dahm, designing engineer, in a discussion in the Proceedings of the Municipal Engineers of the City of New York for 1907.

The tests were made with ¾-in. and ⅞-in. rods embedded to a depth of 9 ins. in 8 × 8 × 12-in. concrete blocks. Some of the rods were deformed to give mechanical bond and others were plain, some were clean when embedded and others were rusted, painted or oiled. It will be seen from the tabular statement of results that painting or oiling the rods caused them practically to lose all hold on the concrete.

Kind of Rod.	Age in days.	Total pull, lbs.	Adhesion per sq. in., lbs.
¾-in. sq. rusted	30	11,800	437
¾-in. sq. clean	30	9,260	294
¾-in. sq. red lead	30	1,700	63
¾-in. sq. oil	30	900	33
¾-in. twisted clean	25	13,550[1]	500
⅞-in. sq. clean	30[2]	4,610	146
⅞-in. Thacher clean	30	17,150[3]	700
¾-in. sq. graphite	30	270	10
⅞-in. Thacher clean	30	19,450[4]	788
¾-in. twisted clean	25	14,030[5]	520
¾-in. sq. graphite	30	650	24
⅞-in. Thacher clean	30	11,120[4]	450
⅞-in. Thacher clean	30	10,200[4]	410
¾-in. twisted clean	30	12,330[4]	457
¾-in. twisted clean	30	15,190[4]	560
¾-in. sq. rusted	90	17,350[4]	642
⅞-in. sq. clean	90	13,590[4]	431
¾-in. sq. red lead	90	3,460	128
¾-in. sq. oil	90	1,700	63

Notes—[1]First drop at 9,000 lbs., block split; [2]In water; [3]First drop at 13,910 lbs., block split; [4]Block split; [5]First drop at 6,470 lbs., block split.

From the above report, you will note that rusty steel in some cases shows up better than clean, while in other cases it does not. You will also note that rods painted with red lead in one case, showed a total pull of 1,700 lbs. a unit adhesion of 63 lbs. per sq. in., and in another case where the age in days was three times as great, the total pull increased to 3,460 lbs. or 128 lbs. per sq. in. more than double. You will also note that rods painted with graphite paint in one case showed a total pull of only 270 lbs., 10 lbs. per sq. in., and in another case, with the same size rod, a total pull of 650 lbs. or 24 lbs. per sq. in. This shows the necessity of a careful selection of the paint pigment to be used on rods when painted. Many of the graphite pigments are natural lubricants, hence should not be used for adhesion tests. Red lead as shown, is very much better, and a high quality of iron oxide properly mixed, and applied, would show even a higher percentage than red lead.

When the concrete can be made absolutely waterproof, and there is no danger from electrolysis, it is then unnecessary and detrimental to paint the rods, but where the concrete cannot be made absolutely waterproof, the rods should then be painted, as the best choice between two evils.

In support of the above statement, I beg to call your attention to a paragraph in an editorial of your issue of Sept. 26, 1907, p. 340.

> And if the steel in reinforced concrete does rust, it means not merely the weakening of the steel; but the actual disruption of the concrete itself, which is a still more serious matter. When iron or steel rusts, as everyone knows, it increases largely in volume. If a rod embedded in concrete forms rust of any considerable amount, the concrete will be burst open by a force as resistless as that of freezing water.

One of my main reasons in calling the attention of your readers to a difference of opinion in regard to your editorial, is because it seems to reflect upon this particular organization of Maintenance-of-Way & Master Painters, of which I have been an Associate Member ever since they were organized. This association is composed of practical men, and while young in years has done good work, I regret that you picked out from their proceedings this particular question and jumped on it so hard, and omitted some complimentary remarks that might have been made about valuable information that was brought out by the Master Painters themselves. Constructing engineers can and do secure very valuable information from these same master painters. This particular subject will require a number of years of continuous testing before the matter is decided positively, as to whether it is best to paint (under the present existing conditions) or to leave it unpainted, with the hope that no serious damage will be done.

There is also to be taken into consideration the effects of the electrolytic action of stray currents on iron embedded in concrete, and the possible prevention of such corrosion, and this point must be settled before deciding the question of "To Paint or Not To Paint," and in this connection, I would state that this problem is now undergoing examination at the Massachusetts Institute of Technology, and we are supplying samples of various paints to that Institute for tests along that line.

The matter is a serious one, and I beg to add a few statements that were made in my last book (Seventh Edition), "Review of Technical Paints for Metal" on this particular subject, which I am following up and trying to solve.

REINFORCED CONCRETE AND CEMENT COATING.

There has been published in several trade papers an article advocating the use of a thin coating of cement on iron or steel to prevent corrosion. A thin coat, even if it could be applied successfully and remain on without cracking (two impossibilities), would not prevent corrosion for a very long period for the following reason:

The cement for a while would take up the oxygen, thus allowing only pure water to reach the iron, and pure water will not cause rust, but after a while the cement reaches its limit as regards the taking up of the oxygen, and from then on ceases to be a protector of the iron. The trouble with this cement experiment, as with many others, is that it was not given a sufficiently long-time test.

If the concrete is several feet thick, free from cracks, and not exposed to running water, it will better protect iron or steel from corrosion, especially where it is below the water line and gets constant immersion, but all metal that is to be embedded in concrete should be protected with paint.

In a paper read before the American Institute of Electrical Engineers at New York, March 1, 1907, the following conclusions were presented as the results of research that has been carried on for several years to ascertain whether concrete will afford protection to iron and steel against electrolytic corrosion:

"1. Steel structures are well preserved from ordinary corrosion by concrete if placed either in salt or fresh water. This, however, has long been known.

"2. If but a small fraction of an ampere of electricity passes from an interior metallic column or structure into concrete or masonry as usually made, there will be corrosion of the metal and disintegration of the concrete or masonry.

"3. Structures of steel in concrete that are subject to sea water are in more danger from electrolytic action than those in fresh water, by reason of the lower resistance of concrete in sea water, as shown by the laboratory experiments.

"4. In no sense can concrete be considered an insulator, and it is from all appearances just as good an electrolytic as any of the soils found in the earth."

We quote from the 1904 Report Committee E, American Society for Testing Materials:

"The protection afforded by cement coatings, though of recent introduction and limited application, seems worthy of further investigation. At present this coating requires a moist atmosphere while setting, a condition hard to meet in practice. Its action depends not so much on impenetrability to moisture as on the neutralization of carbon dioxide and acid gases, etc. This action is so different from oil paint films that a comparison of these two types of coatings will be difficult."

Dr. W. H. Walker, in a paper read before the New York section of the American Chemical Society on May 10, 1907, stated that carbon dioxide is not necessary in order to produce corrosion, while it does accelerate the corrosion. Oxygen alone will produce corrosion without any carbon dioxide in connection with it.

The rust-forming agency is a solution of oxygen in water. This consitutes the whole secret of the production of rust. Hence, it follows that other conditions being equal, cold water is more active in producing rust than hot, and iron rusts much more rapidly when the contact with water is intermittent than in cases of permanent immersion.

I would be very glad to see a discussion opened up in your columns in regard to the subject of painting reinforcing steel for concrete work, as no doubt valuable information could be brought out.

Frank Cheesman,
Member American Society for Testing Materials.

National Paint Works, 10 William St., New York City, April 17, 1909.

[The safety of reinforced concrete depends entirely upon the bond between the steel and the concrete. Without that bond, which is more largely due to adhesion than to mechanical obstruction, the transmission of stress from the one material to the other is impossible. Now, so far as we know, all paints or protective coverings which are now on the market practically destroy any adhesive connection between the two materials by, as we said in the editorial, "substituting two planes of poor bond, concrete to paint and paint to steel, for the one strong bond of concrete to steel."

Granting that in cases of poorly mixed concrete or in construction under heavy water pressure, there is a possibility of infiltration of water to the reinforcement with a consequent corrosion of the metal, what does it avail to paint that metal and injure immediately the present strength of the structure as a safety measure against a possible decreasing strength in the future.

If a paint can be devised which, under test, shows a bond equal to the original bond of concrete and steel, such a paint might prove of value in certain exceptional cases where water penetration is expected, but the main protection against the corrosion of the iron must be in the concrete itself. The water should not be allowed to get as far as the steel. As to the dangers of electrolysis, Mr. Cheesman's own notes confirm the present lack of knowledge of the amount of danger to be expected therefrom. In tests where the current is directly applied under most favorable conditions, there is a marked destructive action on both concrete and steel, but the extent to which this action will hold in actual practice where only stray currents are to be expected—for direct connection must be insulated against outside the concrete—is still a matter of conjecture.

Exception must be made to our argument, in the case of steel embedded in concrete, where the concrete acts only as a coating, such construction, for instance, as the concrete encased grillage beams in building foundations. Here the bond of concrete to steel is not figured on and the painting of the metal can do no harm to the strength of the structure. In our editorial we referred to reinforced concrete, by which we imply the interdependence of the two materials in taking their respective stresses. The paper that we criticized made no distinction between reinforced concrete and steel embedded in concrete, and entirely disregarded the matter of bond.

In regard to any possible criticism on our part of the Maintenance-of-Way Master Painters' Association we certainly disclaim such intention nor do we think that the assumption is warranted by our editorial note. One of the first principles of an engineering association, or in fact of any association, is that it is not responsible for the views expressed by members or in papers presented to the association, unless such views are endorsed by express vote of the society. As we specifically stated that the opinions with which we disagreed were from a paper read before the society, our criticism was directed against the writer of that paper and toward him alone.—Ed.]

A Unique Belt Conveyor.*

By E. C. SOPER,† Jun. Am. Soc. M. E.

It is quite possible that a description of a belt conveyor a quarter of a mile long, and requiring more power to operate empty than loaded, will be interesting to some of the members and since its installation and operation are at variance from the prescribed rules of conveyor design, we beg to submit the following:

The belt conveyor was built during the summer of 1908 in one of the large Portland cement plants of the

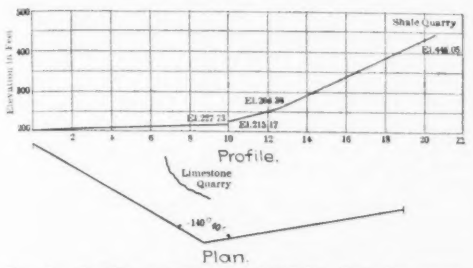


Fig. 1. Profile and Plan of 2000-Ft. Belt Conveyor.

(Length of lower section, 998 ft. c. to c.; upper section, 1,082 ft. c. to c.)

South. It consists of a 24-in. 8-ply canvas belt in two sections, one section about 1,000 ft. between centers, and the other with 1,100 ft. between centers, its function being to convey the shale used in the manufacture of the cement, from the shale quarry to the plant. The shale deposit is located on a mountain about 247 ft. above the shale storage tanks, as shown in profile, Fig. 1. The two sections intersect at an angle of 140 deg. 40 min., so that the blasting from the limestone quarry does not interfere with the operation of the belt. The belt conveys the shale around the limestone quarry, as shown in plan, Fig. 1, and down-hill, as shown in the elevation, and to this latter fact is due the apparently paradoxical results in power required to operate, shown in Tables 1 and 2.

The belt is flat and carried by rollers, the top row having 4 ft. between centers and the return idlers 12 ft. between centers. (See Fig. 2.) Guide rollers are placed with about 40 ft. between centers along both upper and lower belts. The majority of manufacturers of belt conveyors recommend the maximum length between centers of a single belt to be about 700 ft. to 800 ft.

Because of the extreme length of the belt, and the fact that there is no roof or other covering, it was necessary to install some system for taking care of the expansion and contraction, in addition to the ordinary stretch of the belt, which is taken up in the majority of installations by 24-in., 36-in., or 48-in. take-ups, according to length of belt. A set of 36-in. take-ups, (Fig. 3) was installed at the upper end of each of these belts to maintain alinement and equal tension on each edge of the belt. The system installed acts as a tension carriage and makes it less often necessary to cut out the slack in the belt, and in cool and wet weather the belt adjusts itself, the contraction raising the weight in the tower. A 10-HP. motor drives each section. The lower section has a 6-ft. drop and requires approximately 5.1 HP. to operate empty and 5.1 HP. to carry a load of 1,200 lbs., as shoveled by ten men. The discharge from the upper to the lower sections through a chute is shown in Fig. 5. There is no spilling of material at any point of the travel, and pieces of shale a cubic foot in size are carried. The upper section is driven, contrary to practice, at the upper end, the pull being on the lower or slack side of the belt, but in this case, due to the pull of gravity on the top side, the belt was found to work better with the pull on the lower side.

The several halftones give views of the belt taken from different points. In clearing a way through the woods, the poles obtained were utilized for trestling and the planking was obtained from the scrap pile of concrete-form lumber.

Fig. 4 is a side view of the lower end of the upper section, showing the two depressions in the belt, and though these depressions do not conform closely to the prescribed radius of 300 ft., there is no lifting of the belt from the carrying idlers.

Power tests were made on the two sections after the belt had been operating a few days, with the following results: in the lower section, which has a grade of 2.4% for 665 ft., or $0.024 \times 665 = 16$ ft., the speed of the belt was 146 ft. per min.; the belt was driven by a 10-HP. direct-current motor, and was loaded 2.2 lbs. per ft. for a distance of 550 ft., a total of 1,210 lbs.; this load fell 16 ft. in 5 min. Then the work done by the load was

$$\frac{1,210 \times 16}{5} = 3,520 \text{ ft.-lbs.}$$

or the power helping to pull the belt was

$$\frac{3,520}{33,000} = \frac{1}{11} \text{ HP. (approximately.)}$$

When the belt was loaded as above, a test of the motor showed that 16 amperes at 239 volts, or 5.1 HP., were required. There was no appreciable difference in the ammeter and voltmeter readings when belt was empty or loaded.

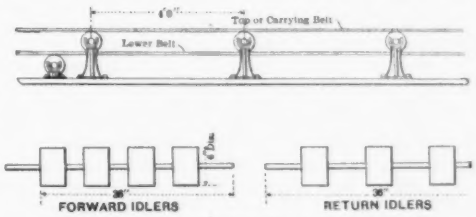


Fig. 2. Details of Idlers for a Unique Belt Conveyor.

When the belts were installed, after trying them out and ascertaining how easily they could be operated, a sprocket was placed on the tail-shaft of the lower section and also one on the head-shaft of the upper section, and the two sprockets were connected by a vertical quarter-twist chain. The idea was to drive both belts by a 10-HP. motor at the head of the lower belt section, after all shafts had become well seated in the bearings and the stiffness had disappeared from the belt and it was in

TABLES I AND 2.—POWER TESTS OF A UNIQUE BELT CONVEYOR.

First Series.

Time (A.M.)	Volts	Amperes	Watts	HP.	Notes.
9.50	207	12	2,484	3.3	Belts chained together; 8 men loading.
10.08	210	12	2,520	3.3	
10.09	208	14	2,912	3.9	Con'ct'g chain off, 10-HP. motor only.
10.11	210	14	2,940	3.9	
10.15	200	14	2,800	3.7	Gradual increase in electrical load due to decrease in shale load.
10.20	200	15	3,000	4.0	
10.35	200	16	3,200	4.2	

Note.—Low voltage due to very small mains and long distance (2,500 ft.).

Second Series.

Time (P.M.)	Volts	Amperes	Watts	HP.	Notes.
2.00	194	16	3,104	4.1	Empty. Connected to lower belt by chain.
2.15	180	16	2,886	3.8	All readings at motor and not including line loss.
2.25	182	18	3,275	4.4	
2.35	186	18	3,348	4.4	
3.45	195	14	2,730	3.6	Loaded by seven men.
3.50	185	19	3,515	4.7	Loaded as before, but with connecting chain off. 10-HP. motor only.

Note.—Readings taken on motor at upper end of belt-section.

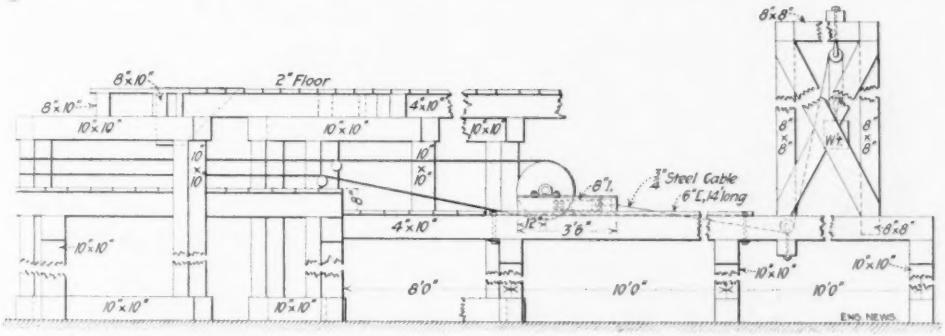


FIG. 3. TAKE-UP AND TENSION EQUALIZER FOR 2,000-FT. CONVEYOR BELT.

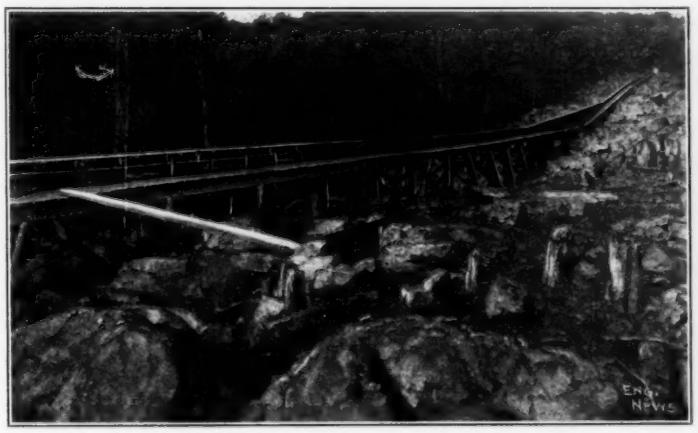


FIG. 4. UPPER SECTION OF CONVEYOR.

FIGS. 4, 5 AND 6. A UNIQUE BELT CONVEYOR 2000 FT. LONG.

(Due to the effect of gravity on the loaded belt, this conveyor requires less power to drive it loaded than empty.)

FIG. 5. INTERSECTION OF UPPER AND LOWER SECTIONS.

FIG. 6. LOWER SECTION AS SEEN FROM ABOVE.

*Presented at the Washington meeting, May 4-7, 1909, of The American Society of Mechanical Engineers.

†Ford Bldg., Detroit, Mich.

good operating condition. This was also necessary in order to take up the slack in the upper section when starting, and *the speeds were such that the top side of the belt ran 3 ft. per min. faster than the lower side.* The results of a series of tests are given in Tables 1 and 2.

Initial and Operating Costs.

Tables are given herewith upon the first cost of the equipment (Table 3) and the cost of operation and maintenance (Table 4). Table 4 is based upon a capacity of 200 tons conveyed in ten hours. Inasmuch as the capacity is directly proportional to the speed, if it was desired to increase the capacity of the conveyor, it would only be necessary to increase the travel of the belt per minute, and from experience, it seems quite possible that by doubling the load the power required to operate would be reduced 50%.

TABLE 3.—COST PER FOOT OF COMPLETED BELTS INCLUDING ELECTRICAL MOTORS, TRESTLING, ETC.

Materials	Total cost.	Cost per ft.
Lumber	$496.34	$0.238
Belt	5,361.52	2.58
Castings	1,435.77	0.69
Electrical equipment, including two 10-HP. motors	637.11	0.316
Miscellaneous: nails, bolts, screws, iron, etc.	193.20	0.093
Labor	962.20	0.46
	$9,106.16	$4.37

Note.—Length of first section, center to center, 998 ft.; second section, 1,082 ft.; total, 2,080 ft.; takeup, 15 ft. Cost of castings includes machine work, etc.

TABLE 4.—COST TO OPERATE AND MAINTAIN BELT CONVEYOR.

		Per 10-hr. day.	Per ton.
Power.			
10 HP. at $0.004 per HP.-hr.		$0.40	$0.002
Labor.			
Boy oiling, etc.	$0.75		
Taking up slack once in 7 days, 2 men, 3 hr. at $0.20 per hr.	0.171	0.92	0.0046
Supplies.			
Belt Lacing	0.10		
Waste, Resin, etc.	0.10	0.20	0.001
Total		$1.52	$0.0076
Oil (no charge, using waste oil from large crushers).			
Interest, etc.			
Interest, Depreciation, Renewals, 10% on investment of $9,200.		2.52	0.0126
Grand Total		$4.04	$0.0202

The operation costs given in Table 4 are taken from actual practice. Doubling the capacity per day, assuming above costs to remain approximately the same, reduces the actual cost of conveying to $0.0038 per ton. Interest and depreciation, $0.0063, or a total of $0.0101.

In the operation of the belt, after the stiffness had disappeared, there was very little slipping at the head or drive pulleys, and there was sufficient lubrication in the shale itself to form a waterproof covering about ⅛-in. thick on the belt, thereby protecting it not only from wear but from the action of the elements, and proving a very good dressing to keep the belt pliable. Because of the slow speed, etc., there are very few repairs necessary to the belt, and in this instance, being coated as described above, the belt should last several years.

THE PURCHASE OF COAL ON ITS HEATING VALUE by the U. S. Government is reported, by the Technologic Branch of the U. S. Geological Survey, to have effected a saving of $200,000 in the annual fuel bill of the Government, which now aggregates about $10,000,000. At the present time, 40 departmental buildings in Washington, more than 300 public buildings throughout the United States, the Panama R. R., navy yards and arsenals are buying their fuel supplies on specifications fixing the amount of ash and moisture.

The actual quality and value of the coal delivered is determined by analyses of representative samples and deductions are made from the contract price, in case of deliveries of poor coal, proportionate to the decrease in heating value. Premiums are paid for any decrease of ash greater than 2% below the specified amount at a rate of 1 ct. per ton for each per cent. and deductions are made at an increasing rate for each per cent. of ash in excess of 2% above the standard.

A PROPOSITION FOR WOOD PAVING in a portion of the financial section of Boston has been creating much local interest of late. Mr. Guy C. Emerson, M. Am. Soc. C. E., Superintendent of Streets of Boston, has recommended that wood be laid on Congress, State and Exchange Sts. and on Merchants' Row. The business interests and property owners abutting on these streets seem to be strongly in favor of the wood pavement, but there appears to be much opposition from teamsters and teamsters' associations, express companies and the Society for the Prevention of Cruelty to Animals.

A New Transmission Dynamometer.*

By WM. H. KENERSON,† M. Am. Soc. M. E.

The author has received from time to time many requests for a simple transmission dynamometer, and has himself often felt the need of one which would be more generally applicable than those now in use. These continued requests, together with the requirements of a definite problem whose solution demanded a rigid transmission dynamometer in the form of a coupling, led to the design and construction of the instrument described below. The accompanying illustrations show the construction of the dynamometer and its method of application and use.

The couplings *A* and *B*, each keyed to its respective shaft, are held together loosely by the stud bolts *C*. The holes in the flange *A* are larger than the studs *C*, so that these studs have no part in transmitting power from one shaft to the other. The power is transmitted from *A* to *B* through the agency of the latches *L*, four of which are arranged around the circumference of the flange *B*. These latches are mounted and are free to turn on the studs *E*. The two fingers of the latches engage the studs *F* on the flange *A*. On the ends of each

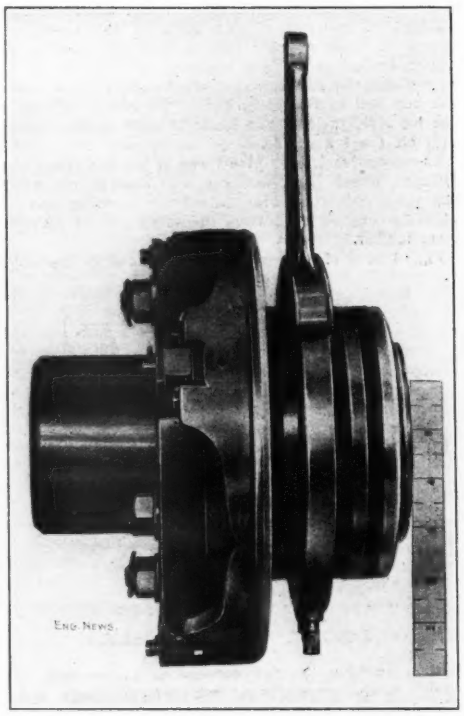


Fig. 1. A Sensitive Transmission Dynamometer in the Form of a Shaft Coupling.
(Coupling shown was designed for a 2-in. shaft and weighs 60 lbs.)

latch are knife-edges parallel to the stud about which the latch turns. For either direction of rotation of the flange *A*, the latches *L*, which are in effect double bell-crank levers, will exert a pressure on the disk *G*, tending to force it axially along the hub of the coupling *B*, and this pressure, it will be seen, is proportional to the torque.

Between the end-thrust ball, or roller, bearings *M M*, is held the stationary ring *S*, which is the weighing member. *O* is a thrust-collar screwed on the hub of *B*, and *P* is its check nut, which is ordinarily pinned to the hub when in position. The stationary member *S*, in the form of a ring surrounding the shaft, is prevented from rotating by fastening to some fixed object the attached arm shown in the view (Fig. 1) of the assembled instrument. In this ring is an annular cavity covered by a thin, flexible copper diaphragm *D*, against which the ball-race of one of the thrust-bearings presses. The edge of this ball-race is slightly chamfered to allow some motion to the diaphragm. The cavity is filled with a fluid, such as oil, and connected by means of a tube to a gage. The oil pressure measured by the gage is proportional to the pressure between the thrust-bearings, which in turn is proportional to the torque.

The instrument may be calibrated in the torsion-testing machine or by means of a sensitive friction brake. Fig. 2 is an actual calibration curve for a small instrument, obtained by hanging standard weights at proper distances from the shaft on a horizontal lever attached to the shaft, and reading the pressures indicated by the gage for the various torques shown in the diagram. For ordinary purposes, however, it is not necessary to calibrate the instrument by actual trial, since computations of the oil pressures for the various torques from the lengths of the lever-arms and diaphragm area check very closely those thus obtained.

It will be seen that the weighing means is similar to that employed in the Emery testing-machine, which is recognized as being extremely accurate. It will be possible to employ the Emery flexible steel knife-edges on the levers, if desired, but this has been found in practice an unnecessary refinement.

The construction makes the coupling as nearly rigid as materials will permit, the movement of the diaphragm being extremely small. The only flow of oil through the copper connecting-pipe is that sufficient to alter the shape of the Bourdon tube, if that be the form of gage employed. As soon as the normal position of the gage is reached this flow ceases, hence there can be no fluid friction. It is possible, therefore, to use as long and as small a tube as desired, without introducing error. Where the gage is placed at a distance above or below the coupling, correction should of course be made for the static head.

Other means than the gage shown may be employed to measure the fluid pressure. Where extreme accuracy is desired it will be well to employ the weighing-device used with the Emery testing-machine. The manograph has been used in this connection to measure variations in torque too rapid for indication by the ordinary gage. For example, the variations in torque in a single revolution of the shaft of a 3-cylinder gasoline engine have been recorded with its aid.

Where the rate of rotation of the shaft is variable and it is desired to indicate the horsepower direct, the combination of gage and tachometer shown in Fig. 3 is employed. The hydraulic gage is connected to the coupling described, its pointer therefore indicating torque. The pointer of the tachometer shows the number of revolutions per minute. Being a function of the revolutions per minute and the torque, the horsepower will be indicated by the intersection of the two pointers and suitable curves on the dial as shown. Arrangements for recording or integrating the work done may also be attached to the coupling.

A summary of some of the more important characteristics of the instrument follows:

1. The instrument is compact. The example shown in Fig. 5 and Fig. 6, which is designed to transmit 30 HP. at 500 r. p. m., is about 5⅝ ins. in diameter and weighs about 25 lbs. That shown in Fig. 7 driving a 3-in. shaft is about 13 ins. in diameter and weighs about 100 lbs.

2. It is as rigid as an ordinary flange coupling.

3. It may be made in the form of a coupling, and will then occupy about the same space as the usual flange coupling, or it may be made in the form of a quill on which a pulley is mounted. This form may be made in halves for application to a continuous shaft.

4. It will indicate for either direction of rotation of the shaft.

5. The torque may be read and recorded or the work integrated at a considerable distance from the coupling.

6. The readings do not require correction for different speeds of rotation. All parts containing oil are stationary, hence are unaffected by variation in speed. Other parts are likewise unaffected by centrifugal action.

7. It may be made very sensitive and accurate. The construction lends itself very easily to variation of range

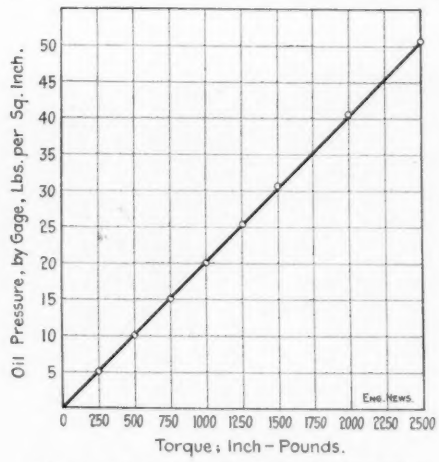


Fig. 2. Calibration Curve for Transmission Dynamometer.

of application and to varying degrees of sensitiveness, since the oil pressure, and hence the sensitiveness of the instrument, depends upon the area of the diaphragm, the relative lengths of the arms of the latches *L*, and the diameter of flanges. Its accuracy is dependent mainly on the degree of accuracy of the means employed to measure the fluid pressure, of which a number

*Presented at the Washington Meeting, May 4-7, 1909, of the American Society of Mechanical Engineers.

†Associate Professor of Mechanical Engineering, Brown University, Providence, R. I.

of forms, other than the usual pressure-gage, are available.

8. The only power absorbed is the small amount due to the friction of the ball, or roller, bearings, and this can be determined from the pull of the retaining arm. It is unnecessary to make correction for this, however, since the amount is so small as to be negligible.

9. Since the only wearing parts are the ball, or roller,

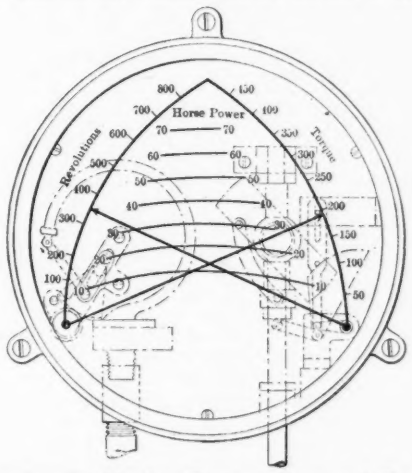


Fig 3. Combination Pressure Gage and Tachometer for Use with New Transmission Dynamometer.

(This gage indicates torque, revolutions per minute and horse-power.)

bearings, which may be lightly loaded, the instrument should not be deranged easily. Because of the very small volume of oil contained in the weighing chamber, ordinary temperature changes do not affect the calibration. All parts containing oil are stationary, hence all joints may be soldered and leakage entirely prevented.

10. With suitable material and ordinary workmanship, it is believed that there is little likelihood of failure of any part of the instrument. It is conceivable, however, that the balls or rollers, although lightly loaded, might crush; the diaphragm might shear; or the stationary member, although bearing only its own weight and lubricated, might seize to the hub. Remote as are any of these possibilities, should any or all of them occur, the worst that could happen would be the tearing-off of the oil pipe and retaining arm, when the whole would revolve as a solid coupling. In no case can the coupling fail to drive the shaft because of its variation from the standard form, since, in addition to the driving-latches employed to carry the load normally, the same number of connecting bolts may be employed as in the ordinary coupling, which will still hold the coupling together should the latches fail. Since, however, these latches are farther from the shaft, they should, if properly constructed, be less likely to fail than the connecting bolts usually employed.

It is believed that uses for the instrument here described will suggest themselves, and it is with the hope that the device will prove of some interest to those who deal with the use and transmission of power that the matter is presented to the society.

FOUR MINE RESCUE STATIONS have been recently established by private interests as a result of the introductory work at the Government experiment stations by the Technologic Branch of the U. S. Geological Survey. The four private stations have been installed, respectively, at the Leisingring mine near Connellsville, Pa., by the H. C. Frick Coke Co.; at Fairmont, W. Va., by the Consolidated Coal Cos. of Maryland; at Marianna, Pa., by the Pittsburg-Buffalo Coal Co., and at the Zeigler mines in Zeigler, Ill. At each of these stations a rescue corps is being trained in the use of the oxygen helmet.

STAYBOLTS OF ELECTROLYTIC COPPER have given bad results in locomotives on Prussian railways in the last few years, according to a statement by Mr. Metzeltin in the "Zeitschrift des Vereines Deutscher Ingenieure" of April 24, 1909. An unusual number of staybolt fractures occurred during recent years, in a period when electrolytic copper was adopted as material, in place of furnace copper. As many of the fractures occurred on wide fireboxes, there was doubt as to whether the construction or the material was responsible. Staybolts that broke were therefore collected, for a period, and tested; of 23 samples it was found that only 2 were of furnace copper and 21 of electrolytic copper. Of the electrolytic samples, only one contained arsenic, while all the staybolts of furnace copper showed arsenic. The Italian railways and the railways of the British colonies, it is stated, specify a percentage of 0.15 to 0.55% arsenic in copper.

Spring Meeting of the American Society of Mechanical Engineers, at Washington, D. C.

The annual spring meeting of the American Society of Mechanical Engineers was held in Washington, D. C., May 4, 5, 6 and 7, at the new Willard Hotel. The social and entertainment features of the convention were given great prominence. On the evening of May 4, the first gathering of the society was at a welcoming reception given by the Washington Society of Engineers. The total registration on the last day of the meeting was 289.

On Wednesday afternoon, May 5, there was an exhibition cavalry drill at Fort Meyers. It had been planned that on Friday afternoon the aeronautic corps should manoeuvre a dirigible balloon for the members, but this was prevented by weather conditions. On May 6 the society and guests were presented to President Taft in the East Room of the White House.

There were two evening sessions of a semi-professional nature, yet popular enough to draw a large attendance and to fill the meeting halls. At the first of these, on May 5, Mr. F. H. Newell, Director of the Reclamation Service, was to deliver an address on "Home Making in the Arid Regions." In Mr. Newell's absence, Mr. Arthur P. Davis, Chief Engineer of the Reclamation Service, gave an informal talk. For half an hour colored views were thrown on a screen to show the engineering work of the Western irrigation projects. There were many views showing the amazing fertility of the land, and special care

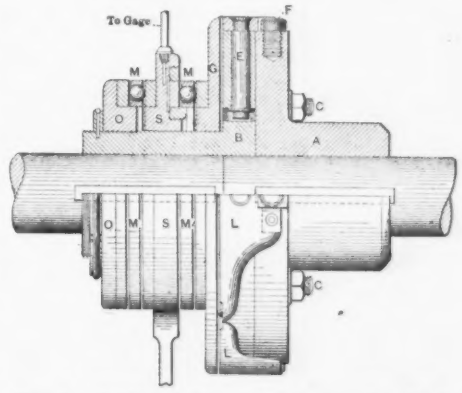


Fig. 4. Sectional View of Dynamometer Shaft Coupling.

(Letters correspond to those in Fig. 6.)

seemed to be taken in showing the great earthern and masonry dams being built.

At the second evening session, a portrait of Rear-Admiral George W. Melville, former Engineer-in-Chief of the Navy, was presented to the National Gallery. The presentation address was made by Mr. Walter M. McFarland, Acting Vice-President of the Westinghouse Electric & Manufacturing Co., of Pittsburg, and the gift was accepted, for the government, by Dr. C. D. Walcott, Secretary of the Smithsonian Institution. Prior to the presentation ceremony, Rear-Admiral Melville read an address on "The Engineer in the Navy." This was a general criticism against the amalgamation of the old Engineer Corps with the line officers and against the necessity of making all line officers into engineers, to a greater or lesser extent. He believed that greater specialization for the design, construction and maintenance of the war vessels, than possible under recent re-

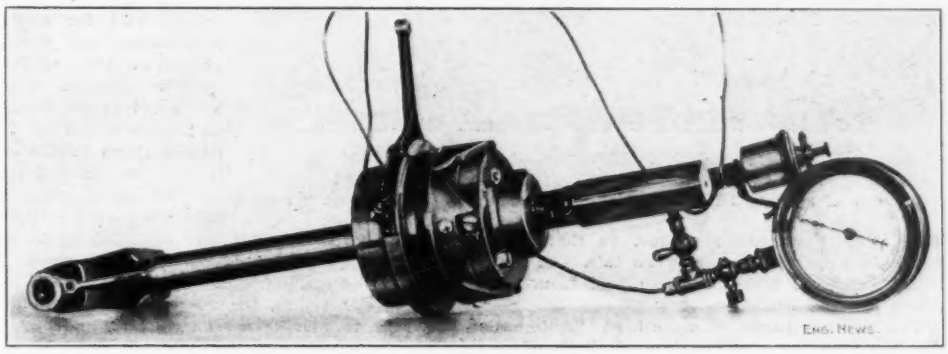


FIG. 5. ASSEMBLED VIEW.

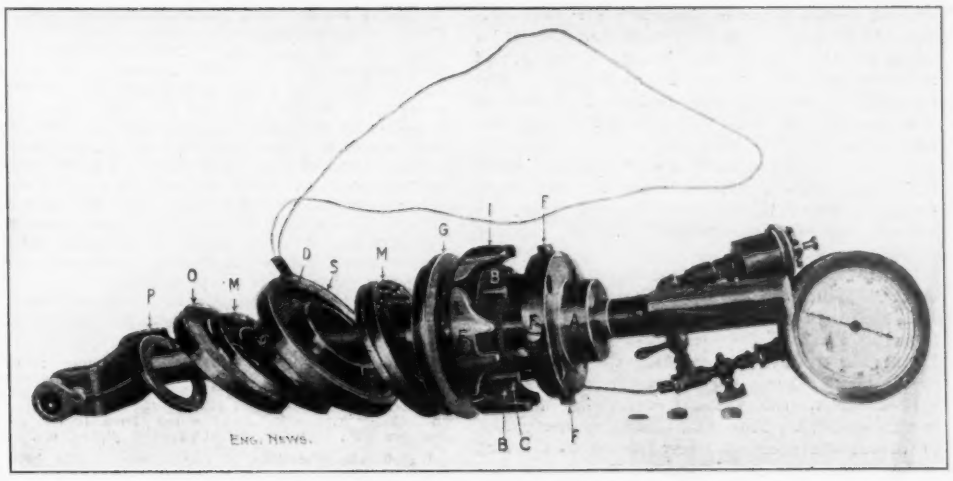


FIG. 6. TAKEN APART TO SHOW CONSTRUCTION.

FIGS. 5 AND 6. TRANSMISSION DYNAMOMETER COUPLING APPLIED TO SHAFT DRIVE OF AN AUTOMOBILE.

(Dynamometer transmits 30 HP. at 500 r. p. m., and weighs only 25 lbs.)

organization plans, would be necessary for proper efficiency. This would necessitate, he held, a distinct engineer corps, composed of special graduates of the Naval Academy and the technical schools of the country, and of the best men rising through the machinists' ranks of the navy.

The professional sessions were comparatively brief, and there was little spirited discussion of the few papers presented. At the first session, on the morning of May 5, four papers were read

—all on matters of rather general interest to mechanical engineers.

The first of these was "A Unique Belt Conveyor," by Mr. E. C. Soper, and is printed in full elsewhere in this issue. It described a two-section flat-belt conveyor, installed in a Southern cement works, for carrying shale around a limestone quarry to storage bins 247 ft. below the deposits. The sections were 998 ft. and 1,082 ft. in length and intersected at an angle of some 140°. As the shale was moved down-hill, less power was required to operate loaded than empty. A 10-HP. motor drove each section, but meter readings indicated a power input of only 3 to 5 HP.

In the discussion on this paper, it was claimed by other conveyor designers that Mr. Soper's belt could hardly be called unique, as there were several in operation as long as this, and some that required a brake, even, to hold them back when running loaded.

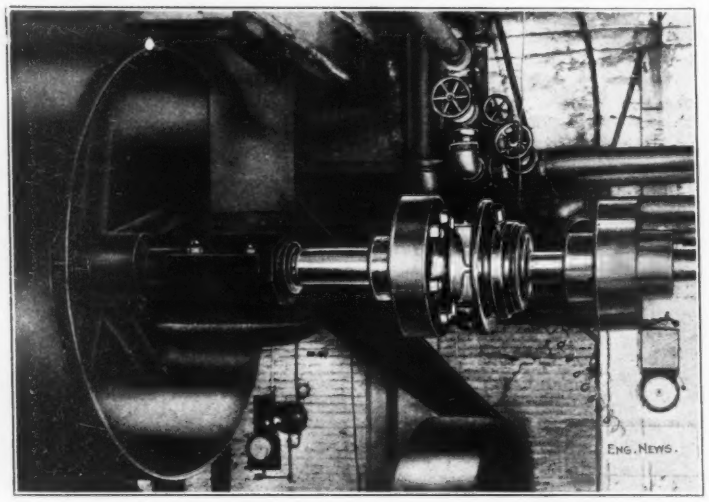


FIG. 7. TRANSMISSION DYNAMOMETER PLACED BETWEEN TWO FLANGE COUPLINGS IN MACHINE-SHOP LINE-SHAFT.
(Diameter of shaft is 3 ins. Spiral oil-pipe from dynamometer to gage is seen at right.)

The second paper was entitled "Automatic Feeders for Handling Material in Bulk," and was written by Mr. C. K. Baldwin, of Chicago, Chief Engineer, Robins New Conveyor Co. This described eleven types of machines for automatically feeding materials to a conveyor, the feeder being started and stopped by the stopping and starting of the conveyor machinery. The essential parts of these feeders consisted of a hopper, in each case, and of undercut and lifting gates, screw conveyors, rolls, paddles, revolving, swinging and reciprocating plates, small belts and aprons, plungers and shaking platforms in the various forms, respectively. The author expressed preference for the shaker feeder.

In the paper, "A New Transmission Dynamometer," Prof. William H. Kenerson, of Brown University, Providence, R. I., described a dynamometer made in the form of a shaft coupling. In this arrangement, on starting, the driving side of the shaft takes a slight angular lead over the driven shaft, the amount depending on the torque exerted. This slight relative movement of the shafts operates curved bell-crank levers which press upon a stationary oil-chamber diaphragm, through ball bearings. The resultant pressure of the oil is recorded by a gage or of any other suitable means, and is proportional to the torque. The instrument is devised also to show the resultant of speed and torque—or horsepower. In the discussion of this paper, hope was expressed that the new dynamometer might soon be adapted for road trials of automobiles, a field of service where great demand was said to be made already by the motor-car designers.

The last paper of the first session was "Polishing Metals for Examination With the Microscope," by Mr. Albert Kingsbury, Mechanical Engineer, Westinghouse Electric & Manufacturing Co. In this, it was related that experiments in this branch of metallography had resulted in the discovery that ordinary paraffin wax made a good polishing bed, and that excellent abrasives and polishing powders were commercially available. Paraffin disks, 8 ins. in diameter, were revolved, at about 200 r. p. m., on the spindle of a polishing machine and were fed with wet abrasions, such as emery and rouge. Small specimens of metals were placed in light contact with the revolving surface.

The polishing was rapid, and gave excellent surfaces on all the hard metals and alloys, but did not prove useful with metals as soft as lead.

The second professional session, on Thursday, May 6, was a meeting of the Gas Power Section of the society, at which four papers were presented.

The first paper, "Marine Producer-Gas Power," by Mr. C. L. Straub, of New York City, was a brief summary of recent progress, with an outline of a recent design of a marine plant. It was stated that two years ago less than 300 HP., aggregate, was developed in marine plants, that these were largely experimental and of the German "Capitaine" type the present aggregate capacity of these types alone is 2,635 HP. The author of this paper claimed that the down-draft producers held far greater possibilities for marine use than the up-draft type on account of the low rates of combustion and non-fixation of the hydrocarbons in the latter. It was stated that in 1908 there were 32 stationary gas-engine power plants of 300 HP. or over having an aggregate capacity of 57,225 HP. Of these, 28 plants aggregating 53,175 HP. were up-draft types. Concerning the adaptation of stationary practice to marine service the author may be best quoted directly:

The plant, as modified to date, has a light compact producer, which while retaining the same rate of combustion as the stationary apparatus, has materially reduced dimensions and weight of shells, brick lining, fittings, etc. The economizer boilers on stationary work have been replaced with light air-heating economizers. The gas-coolers no longer contain any coke or broken material, or wooden trays, and are built of very light, non-corrosive sheet metal, and arranged for either vertical or horizontal positions, the latter arrangement being convenient for space which would be otherwise wasted in the vessel. The cooled and partially cleansed gas is drawn through the above portion of the plant by a centrifugal gas-cleaning exhauster, driven by direct-connected motor. The gas passes directly from the exhauster under pressure, through an automatic pressure regulating valve, to the engine manifold.

That the plant is adaptable for marine service with regard to space occupied and weight, may be seen from the following conservative estimate:

Plants of from 100 to 500 HP. each occupy from 0.4 to 0.5 sq. ft. per HP., and weigh from 70 lbs. to 90 lbs. per HP., including all auxiliaries, piping, etc.; plants of from 500 HP. to 1,000 HP. occupy from 0.03 sq. ft. to 0.45 sq. ft. per HP., and weigh from 40 lbs. to 70 lbs. per HP., including all auxiliaries, piping, etc.

Undoubtedly the rational opportunity at the present time for marine gas power lies in commercial service, in which regard the most rapid advancement in America has been made in the freight, ore and fuel carriers of the Great Lakes.

Mr. Straub showed a design worked out for converting a lake freighter from steam to gas power, but it should be noted that the design has not yet been built or ordered. The boat is 306 ft. over all, 45 ft. beam and 24 ft. deep. Her present equipment comprises a single-screw, triple expansion, condensing engine of 1,050 HP. at 90 r. p. m. and two single-ended Scotch boilers about 12 ft. diameter each with 363¼ sq. ft. grate area and 1,642 ft. heating surface. The proposed gas engine is a four-cylinder, double-acting, reversing type, delivering 1,000 B.HP. at 100 r. p. m. The gas-engine frame is similar to the old steam-engine. All pumps and auxiliaries will be motor driven, drawing current from a 50-KW., direct-current generator directly connected to a double-cylinder, double-acting gas engine. The favored arrangement of producers consists of

two 8 ft. diameter by 9 ft. 6 in. generators, connected to independent air economizers and each fitted with an independent horizontal scrubber, located athwartship under the main deck beams. The gas outlet at the scrubbers will be connected with a cross-over, so that either exhauster may operate either or both producer plants. The exhausters are installed in duplicate and are connected with common purge or blow-off and common gas outlets leading either through one pressure-regulator valve, or through a by-pass direct to the air and gas mixing valves at the engine manifold.

A low-pressure heating boiler will be installed on the producer floor. The coal consumption of this vessel, steam driven, was 1.08 to 2 lbs. per I. HP.-hr. with coal of 13,500 B. T. U. A guarantee of 1 lb. per B. HP.-hr. with bituminous coal of 13,500 B. T. U. has been secured by the designers for the gas plant from manufacturers.

The coal-bunker capacity has been cut in two and the whole rearrangement of the propelling machinery has cut the length of machinery space (including bunkers) from 52 to 34 ft. and has made a saving in space of 11,200 cu. ft.

"Operation of a Small Producer Gas Power Plant," presented by Mr. C. W. Obert, of New York City, Associate Editor of the "Engineering Record," contained a general description of the refrigerating, lighting and power plant at the distributing depot of Swift & Co., in Bronx Borough, New York City. Here two 65-ton ammonia refrigerating machines are driven by two 100-HP. vertical three-cylinder engines. Two similar units are direct connected to two 75-KW., 220-volt, direct-current generators. For gas making, two producer equipments have been installed—one of 200-HP. capacity and the other of 150-HP. Each producer outfit consists of a simple up-draft shell producer, a wet scrubber and a dry purifier. The average plant load is from 100 to 200 HP., according to the season of the year. The plant operates 24 hours a day, 7 days a week, which allows added economy. The consumption of fuel (No. 1 buckwheat) averages from 1.4 to 2 lbs. per HP.-hr. though it has dropped to 1 lb. per HP.-hr. during continuous heavy loads.

The producers have been started from the "cold" condition and in five hours have furnished gas to the engines. The 200-HP. producer in the summer season of 1908 had a continuous service of 235 days with no attention beyond the four cleanings and chargings per day.

The operating force consists of two engineers and two producer tenders, working in two shifts. To the day shift is assigned the work of inspection and adjustment, while the night force cleans the machinery. A regular routine of inspection has been established.

In "A Method of Improving the Efficiency of Gas Engines," Mr. T. E. Butterfield, Chief Engineer of the Otto Gas Engine Works, of Philadelphia, commented on the tendency, in gas-engine practice, to seek higher efficiency by increasing the compression. Then the author described one expedient for avoiding the troubles incident to the high temperatures accompanying the high compression. This measure consisted essentially of diluting the fuel charge drawn in during the suction stroke. He discussed the method of doing this, which was developed some 20 years ago by Mr. John Salter, then President of the Otto Works, and described a few experiments, made in 1899 to 1902, on diluting the charge with spent gases. This was best done by holding open the exhaust valve during a part of the suction stroke. The experiments showed a decrease of fuel per HP.-hr., but also a decrease in maximum horsepower capacity.

Prof. T. M. Phetteplace, of Brown University, Providence, R. I., in the paper "Offsetting Cylinders in Single-Acting Engines" gave a theoretical discussion of four effects of placing the center line of the cylinder out of a plane holding the crank-shaft center line. The paper was largely mathematical and was developed with numerous diagrams. The main conclusions to be drawn were thus summarized:

Offsetting increases slightly the length of stroke and

the crank angle passed over during the stroke toward the crank shaft and decreases the height and weight of the engine.

The work lost in friction due to the side-pressure of the piston on the cylinder walls decreases as the offset increases up to a value of 75% of the crank radius.

Offsetting increases the life of the cylinder and piston.

Offsetting improves the thermal cycle.

The turning-effort curves when the cylinders are offset differ but slightly from those for no-offset.

The advantages of offsetting as regards the maximum side-pressure and work lost may be zero or negative for high inertia-forces resulting from speeds of 1,500 r. p. m. or more.

The third and last professional session was taken up largely with steam engineering topics though there was one paper entitled "Tests Upon Compressed Air Pumping Systems of Oil Wells," by Mr. E. M. Ivens, of New Orleans. This contained a description of several tests on air lifts in the Evangeline (Louisiana) oil field. Here the original plants were crude and were put up with no care to secure efficient operation. The necessity of improving operating conditions was felt when the oil boom dropped with the decrease in production and price.

The old air-lifts were of two general types. First was the "straight-air systems" where the well top was sealed and compressed air was forced in between the casing and the oil-discharge pipe. Air escaping around the bottom of the discharge pipe forced "slugs" of oil out. The second type has a small central air pipe dropped down the middle of the discharge and ending in a simple open end, in a perforated cap or in an upward bent. The casing and discharge pipe are kept as before. The author showed the results of several tests made before and after the installation of an improved design of air lift.

The pumping efficiency was raised, by changing to the new lift, from some 9.5% to 13.4% and 20% and from 12% to 27% in different tests. The system accomplishing these results is a combination of the "straight-air" and "central-pipe." The space between the discharge and the casing is kept under air pressure and the central air line ends in a special footpiece, designed to give the oil discharge a high velocity.

Mr. G. A. Orrok, Mechanical Engineer of the New York Edison Co., of New York City, presented a descriptive paper, "Small Steam Turbines," in which he showed typical sections and views of the several types now available.

At this session was held the discussion on the dimensions of safety valves for stationary, marine and locomotive boilers, aroused by the paper presented by Mr. F. M. Whyte, of New York City, General Mechanical Engineer of the New York Central Lines, at the February meeting of the society. On account of the wide interest and diversified practice shown, the Council of the society referred the subject to the Research Committee composed of Dean W. F. M. Goss, Mr. R. H. Rice, Mr. J. H. Christy, Dr. Chas. B. Dudley, Prof. R. C. Carpenter.

Mr. H. V. Wille, of Philadelphia, Assistant to the Superintendent of the Baldwin Locomotive Works, presented the paper, "A New Departure in Flexible Staybolts," which has already been reprinted in Engineering News (Jan. 21, 1909). The author showed that a 1-in. bolt may be stressed to 48,000 lbs. per sq. in. and proposed to use spring steel for the bolt stems. The ends are of soft steel and permit riveting into the boiler plate.

Prof. C. H. Peabody, of the Massachusetts Institute of Technology, in the paper "The Specific Volume of Saturated Steam" restated the information now available on the properties of saturated steam and recomputed the specific volume at various temperatures for comparison with various experimental determinations. Prof. Peabody showed a maximum discrepancy between computed and corrected experimental values of 1 in 500. He drew the conclusion that since the properties of saturated steam entered this comparison the data now available on these properties fixed them accurately and made steam tables, based on all data now available, practically permanent.

Prof. R. C. H. Heck, of Rutgers College, New Brunswick, N. J., presented "Some Properties of Steam" which was a discussion of recent experimental data on the relation between the pressure and temperature of saturated steam and on the specific heat of water. The work of Holborn and Henning is tabulated in English measures showing the pressure for each degree Fahrenheit from 32° to 462°. Prof. Heck has plotted the results of Regnault, Barnes, Peabody and Dieterici on the specific heat of water and gives an opinion in favor of the latter.

The Collapse of the Reinforced-Concrete Arch Bridge Across the Illinois River at Peoria, Ill.

On May 1, 1909, two piers of a reinforced-concrete arch bridge across the Illinois River, at Peoria, Ill., sank into the bed of the river and then overturned, carrying with them the three arches which they supported. The bridge had been opened for traffic only a few weeks, but no one was on the roadway at the time of the accident, so, luckily, there were no casualties. We have received from various sources information concerning the bridge and the accident, which we present herewith.

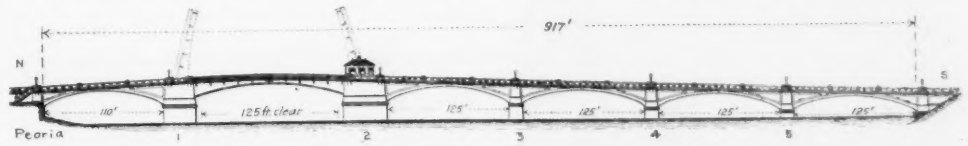


FIG. 1. SIDE ELEVATION OF THE BRIDGE.

Description of Bridge.

The following description of the bridge is taken from a paper entitled "The New City Bridge Across the Illinois River, at Peoria," by Mr. D. H. Roberts, Assistant City Engineer of Peoria, in the "Proceedings" of the Illinois Society of Engineers and Surveyors, 1907:

The bridge will consist of five concrete-steel arches (with the Melan system of reinforcement) and one Scherzer rolling lift span (Fig. 1). The total length on center line will be 917 ft. from out to out of abutments. In addition, on the Peoria side will be an approach 202 ft. long and 27 ft. wide. The width of the roadway will be 25 ft. between curbs and of the two sidewalks, 5 ft. Two concrete-steel stairways will be constructed on the Peoria side leading from the sidewalks to the street grade. The center line of the bridge will conform with the center line of Bridge St., from the end of the approach at Water St. for a distance of 550 ft. to the south pier of the lift span, making the first fixed span and also the lift span practically at right angles to the Illinois River. The bridge will then angle to the south to conform approximately with the center line of the East Peoria road.

There will be an ascending grade of about 4¼% from the end of the approach to the lift span, and a descending grade of about 2¾% from there to the opposite shore or south abutment. The lowest member of the lift span will be approximately 10 ft. above the doubtful extreme high water of 1844, established as a basis by the U. S. Government. The roadway at the lift span will be about 18 ft. higher than the roadway of the bridge.

The first arch between the Peoria bank or north abutment and the lift span will have a clear span of 110 ft., and a rise of 14½ ft. The lift span will have a clear span of 135 ft., and the four arches between the lift span and the south abutment will each have a clear span of 125 ft., and a rise of 13½ ft. The two channel piers supporting the lift span will rest on solid rock 45.25 ft. below the high water of 1844, 26.75 ft. below the established low water mark of the Government, and 18.42 ft. below the zero mark of the city gage at the Lower Free Bridge. The bottom of the concrete in the foundations of the other river piers and the two abutments will be at an elevation of 6 ft. below the bed of the river and will rest on piles, cut off 18 ins. above the bottom of the concrete.

The reinforcement in the arches will consist of 13 longitudinal arch ribs of lattice construction spaced 35 ins. apart. In the 110-ft. arch, these ribs will be 2 ft. in depth at the crown and 4 ft. 6 ins. at the spring line; in the three 125-ft. arches, 2 ft. 6 ins. in depth at the crown and 5 ft. at the spring line. In addition there will be transverse bars ¾-in. diameter spaced 5 ft. apart. The grades of concrete will be as follows: Arches, 1 part Portland cement, 2 parts sand, and 4 parts broken stone that will pass through a 1½-in. ring; spandrel walls, 1 part Portland cement, 3 parts sand and 6 parts broken stone or gravel that will pass through a 2-in. ring; piers, abutments, foundations and retaining walls, 1 part Portland cement, 3½ parts sand, and 7 parts broken stone or gravel that will pass through a 3-in. ring.

Expansion joints will be made in the spandrel walls, cornices and parapets of each arch above the springing line at points one-sixth span from the springing lines.

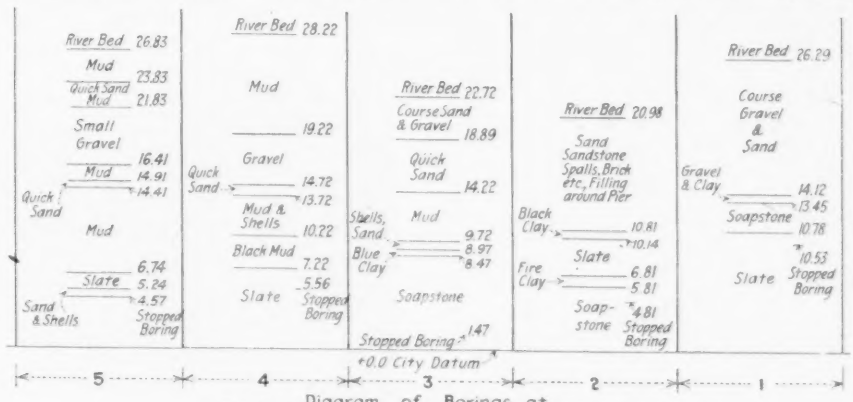
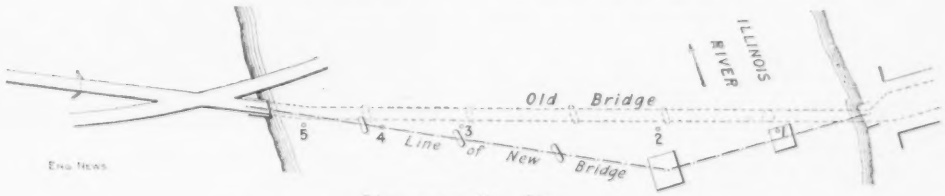


Diagram of Borings at Points indicated on Plan with corresponding Figures



Diagrammatic Plan.

FIG. 2. DIAGRAMS OF BORINGS ON PEORIA BRIDGE.
(Right-hand side is north.)

Provision for drainage will be made at each pier by means of a 4-in. wrought-iron pipe built into the concrete, extending from the center of each space over the piers to the soffit of the arch near the springing line and projecting 1 in. below the soffit. All pedestals, parapets, hand-railings and other ornamental work will be molded. The space between the spandrel walls and retaining walls will be filled with suitable material and rolled to within 18 ins. of the finished grade. The pavement on the fixed spans and approach will consist of gravel 18 ins. in depth after being thoroughly compacted and the sidewalks on the fixed spans will be of cement.

Eye-witnesses to the accident are few. One

of them, the watchman on the bridge, made the following statement, which explains the manner of collapse:

There was a rumbling noise, as if something had struck the big channel pier, where the house is located. Both of us rushed to the door of the house, and when we stepped out we were just in time to see the first arch from the draw on the south side of the big channel pier

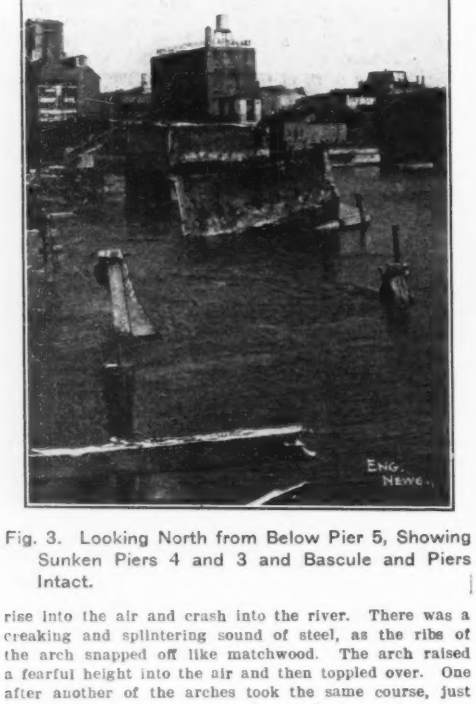


Fig. 3. Looking North from Below Pier 5, Showing Sunken Piers 4 and 3 and Bascule and Piers Intact.

rise into the air and crash into the river. There was a creaking and splintering sound of steel, as the ribs of the arch snapped off like matchwood. The arch raised a fearful height into the air and then toppled over. One after another of the arches took the same course, just like cards standing on end and pushed over.

Immediately following the collapse, we requested Mr. Dabney H. Maury, M. Am. Soc. C. E., to make a report on the accident. Mr. Maury's report, accompanied by views of the bridge after its fall, follow.

Report of Accident.

By DABNEY H. MAURY,* M. Am. Soc. C. E.

At 5.50 A. M., on Saturday, May 1, Piers 3 and 4 of the new Melan reinforced-concrete arch bridge across the Illinois River, at Peoria, settled, and, leaning down-stream as they did so, threw into the river the three arches which they had supported. Figs. 3 to 6 show all that is now to be seen of the bridge.

This catastrophe is the culmination of a long series of mishaps and blunders which have marked the course of the efforts of the city of Peoria to construct a bridge.

About five years ago a contract was let for a steel bridge to replace a structure nearly fifty years old, two spans of which had been carried away by flood.

Fig. 2, which shows the layout of the old bridge and its approaches, also shows the test borings made by the city for the information of bidders on the new steel bridge.

The plans for the steel bridge called for a structure elevated sufficiently to avoid crossing at grade the four railroad tracks on Water St. and the single track of the Toledo, Peoria & Western R. R. on the south bank of the river. This necessitated the construction of long approaches, that on the north side extending about 660 ft. from the north abutment or about to the south line of Washington St.

Objection was raised to this approach by certain abutting property owners, who brought suit to restrain the city from constructing the bridge as proposed, availing themselves for this purpose of the fact that the city could not build the bridge without exceeding its statutory limit of indebtedness. These persons succeeded in stopping the work, but not until the two approaches and two of the piers had been practically finished, at a cost to the city of approximately $50,000. These approaches and one of the piers were afterwards removed.

*Consulting Engineer, Peoria, Ill.

In the summer of 1906 the city advertised for competitive designs for a bridge. The proposal for plans, specifications and certain engineering supervision, submitted by the Concrete-Steel Engineering Co., of New York, was accepted. Under the plans and specifications prepared by that company, contract was let to the Marsh Bridge Co., of Des Moines, for a Melan reinforced-concrete arch bridge, complete with foundations, piers, abutments and approaches. Contract for steel bascule was let to the Scherzer Rolling Lift Bridge Co., which later assigned its contract to the Penn Bridge Co. Contract for the bridge called for its completion by December 1, 1907, but the work progressed so slowly that the bridge was still unfinished at the time of its failure, on May 1, 1909. It is only fair to say that much of the delay was caused by unusually high water.

The bridge consisted of two abutments, with approaches, five piers, numbered from north to south, Piers 1 and 2 being the bascule piers, and five reinforced-concrete arches, one of 110 ft. span, and the remaining four, which were skew-arches, of 125 ft. span.

As there seems to be no question of the fact that the failure originated in the foundations, this discussion may well be confined to a review of the available data bearing upon this feature of the construction.

The borings and other data shown on Fig. 2 were used by the Concrete-Steel Engineering Co. in the preparation of its plans and specifications. It is said that with the exception of two borings made by the United States government at or near the sites of the two piers of the bascule, and which are, unfortunately, not available, no other borings were made before construction was begun. A study of the borings made by the city shows a marked variation in the strata from one boring to another, no two of the five borings giving similar results. It is interesting to note that Boring No. 1 stopped after having penetrated only 0.25 ft. into slate, while Boring No. 2, the next boring south, after passing through more than 3 ft. of slate, found 1 ft. of fire clay before it finally reached soapstone. Boring No. 3 was carried well down into soapstone, but Boring No. 4 stopped after going 1.56 ft. into slate. Boring 5, after piercing 1.5 ft. of slate, would seem, according to Fig. 2, to have been stopped in sand and shells.

The new bridge crossed the river above the line of the borings. With the possible exception of the two piers of the bascule, which did not rest on piles, but were carried down to rock, no boring appears to have been made on the actual site of any pier of the new bridge; and no boring appears to have been made within 100 ft. of either abutment prior to the construction of the piers or abutments.

That portion of the specifications which relates to foundations reads as follows:

3. Foundations.—All foundations shall be as shown on plans, and conform to the dimensions marked thereon. The foundations for north and south abutments, and piers Nos. 3, 4 and 5 will be on piles enclosed by permanent water-tight tongue and grooved sheet piling, or Wakefield piling, and be excavated to the depth shown on plans, and the piles shall be driven after the excavations are made. They shall be sawed off at the elevations shown on plans. The sheet piling will remain in place and be sawed off at least one foot below low water. The spaces between the piles shall be filled with concrete, and in case it is found necessary to lay the concrete under water, proper appliances must be used to ensure its being deposited with as little injury as possible.

The piles shall be oak, yellow pine, or other wood that will stand the blow of the hammer, straight, sound and cut from live timber; trimmed close, cut off square at the butt and top and have all bark taken off. The piles shall be not less than 12 ins. nor more than 16 ins. in diameter at the large end, nor less than 8 ins. in diameter at the small end for piles having a length of 30 ft. and under. For greater lengths the diameter of the small end may be reduced one inch for each 10 ft. of additional length down to a minimum of 6 ins. The piles shall be driven to rock.

The foundations for the abutment piers Nos. 1 and 2 shall be carried down to solid rock. The foundations shall be prepared by removing all sand, mud, or other soft material, and by excavating all loose or disintegrated rock that may be found overlying the solid rock.

The foundations shall be enclosed by cofferdams consisting of two lines of sheet piling securely braced and tied together, the space between them being filled with puddled clay. The strength of the cofferdams and the thickness of puddle must be sufficient to safely withstand any pressure to which they may be subjected and to exclude all water from the foundations during construction. After the completion of the work the cofferdams [on piers 1 and 2—Ed.] shall be removed.

The foundations for the retaining walls at the north approach shall be carried 5 ft. below the grade of street.

In May, 1908, during a high-water period, and while the space between the spandrel walls of the southernmost arch was being filled with earth, the crown of this arch settled approximately 10 ins., and serious cracks appeared. Measurements showed that the south abutment had settled and had also been shoved southward by the thrust of the arch. After three test borings had been made, one south of the south abutment, and one each close to the up-stream and down-stream faces near its northern end, it was finally decided to underpin the south abutment, and the contract for the repairs was let to the Marsh Bridge Co., which began the work during the low water of the late summer and fall of 1908.

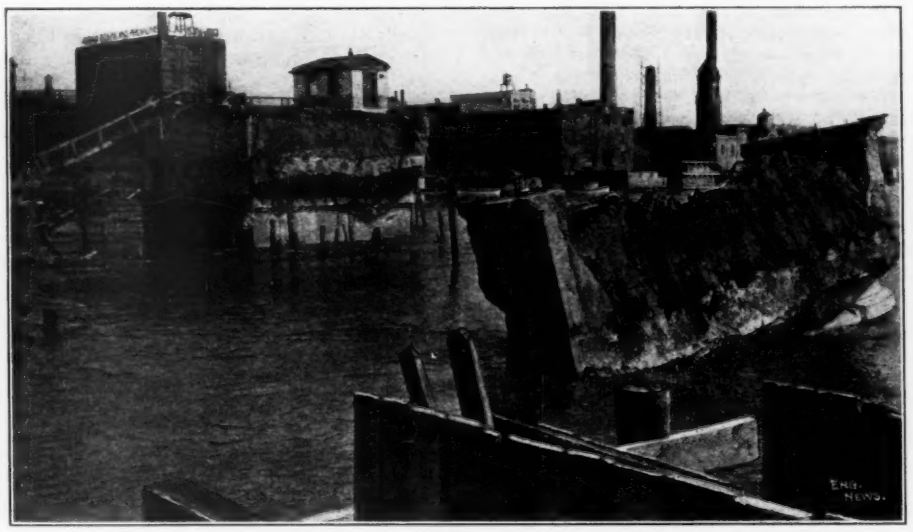


FIG. 4. LOOKING NORTH FROM PIER 4, SHOWING UPPER PART OF SUNKEN PIER 3 AND PIER 2.

Cofferdams were built along the up-stream and down-stream faces of the south abutment, extending well beyond these faces at either end. The earth was excavated to solid rock, being removed from under the abutment to a distance sufficient to permit the construction of a concrete wall, resting on the rock and extending between five and six feet under the edge of the abutment. The wall under and along the down-stream face of the abutment was completed, and extended about 2 ft. beyond the abutment on the north side and about 12 ft. beyond the abutment on the south side, making the base of the new

foundation 47 ft. long instead of 33 ft. long. Of the up-stream wall, which was intended to be like the one just described, only about 15 ft. in length of the northern portion was completed before the work was stopped by high water.

According to the plans for the foundations of this abutment, the front or northerly five rows of piles were to have been driven plumb, while the rear five rows of piles were to have been driven with a batter of one to four, so as to resist the thrust of the arch. However, photographs of the work on the abutment show that the piles are practically vertical, and indicate that they could not have been driven with the batter called for by the plans.

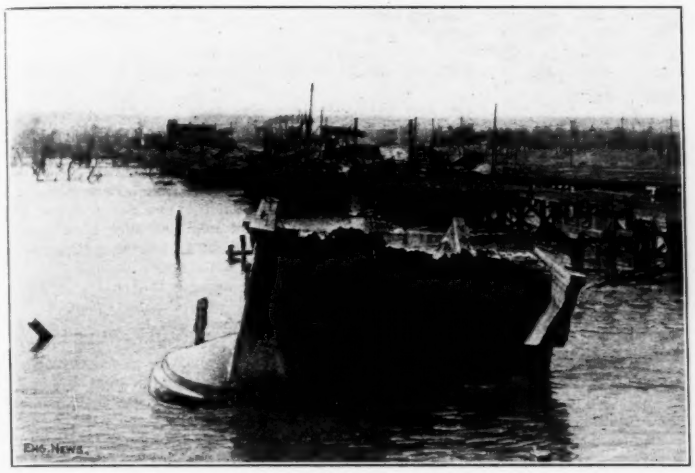


FIG. 5. LOOKING SOUTH FROM PIER 2. PIER 3 IN IMMEDIATE FOREGROUND.

No record appears to have been preserved of the actual depth to which each pile was driven, nor of its penetration under the last blows of the hammer. It is stated, on the one hand, that the piles exposed by the excavations under the south abutment did not go to the solid rock. On the other hand, it is stated that all the piles were driven to refusal, or until further driving would have injured the pile. These statements are not necessarily so conflicting as they might seem, for loose boulders or a thin layer of shale or slate overlying soft material might well bring a pile to refusal at the time of driving; while later on, the scour of the river, the constant load, and the thrust of the arch might combine to cause, in time, considerable settlement or slipping.

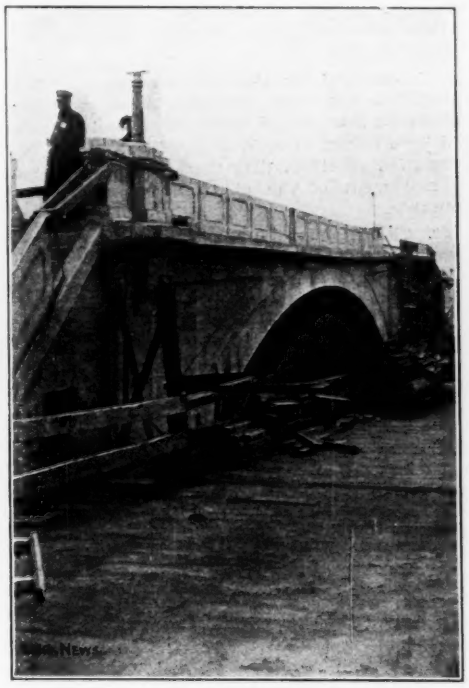


Fig. 6. View Looking South Along Water Table of Most Northerly Arch, Showing the Sag in the Arch.

The general specifications called for permanent cofferdams of sheet piling to be left in place around the foundations of both abutments and of piers 3, 4 and 5. Steel-sheet piling was used for the cofferdams of these piers and abutments, and was afterwards withdrawn.

It is stated that the excavations under the south abutment, and soundings taken at some of the piers, showed that the earth had been scoured out for several feet from under the masonry at these points. Had the sheet piling been left in place, its presence would have tended to prevent scouring.

Pier 3 is said by eye-witnesses to have been the first to topple over. While the exact sequence of events leading up to the failure of this pier will probably never be known with certainty, it seems not unlikely that some, if not all, of the following causes contributed to the result:

Some of the piles may not have reached solid rock, but may have rested upon boulders or a thin shell of slate or shale overlying a soft stratum. The scouring said to have been caused by previous floods was doubtless increased by the high water immediately preceding the failure. The force of the flood would naturally increase the pressure on the down-stream piles, and some of these, deprived by the scour of the bracing effect, as well as of the frictional resistance, of the soil which originally surrounded them, may have buckled or slipped, thus throwing more load on the nearest remaining piles. The failure of these, in their turn, may have thrown more load on to the next, until finally the whole pier toppled over. The fall of Pier 3 doubtless put too much strain on Pier 4, which rested on similar foundations. It might have been expected that Pier 5 would also be involved, but this pier stood the strain, possibly because, being nearer the shore, its foundations had not been so much affected by scour as had those of the piers where the current was swifter and the water deeper.

Piers 1 and 2, which were carried to rock, remained undisturbed; and the bascule, which was closed at the time of the wreck, was afterward operated without a hitch. The northern arch, between Pier 1 and the shore, has been settling progressively, and as shown by Fig. 5, now has a sag of about 5 ins. in the center.

Cracks in the Bridge.

In connection with the condition of the foundations of the piers, the following extract from a letter from Mr. J. W. Woermann, M. Am. Soc. C. E., Assistant Engineer, U. S. Army, is interesting:

Sir: As you are no doubt anxious to secure all the data you can relating to this failure, I submit herewith two sketches which I made on the ground last July. I should say, in the beginning, that at the time work was started on the city bridge, the writer was resident engineer under Ralph Modjeski, on the "McKinley Bridge" for the Illinois Traction Co. This is located about two blocks below the city bridge.

The channel piers of the concrete bridge which failed are founded on bed rock, and the others were founded on piles, which were designed to go to bed rock. At the time the piles were driven for the south abutment I received a tip, which came from one of the men on the pile driver, that some of the piles were too short to reach bed rock. I reported the matter to the chairman of the Bridge Committee and predicted trouble at that time, which was during the winter of 1906-07. I was told the inspector scoffed at the idea and the matter was dropped.

I did not notice any batter piles being driven to resist the horizontal thrust of the arches. In making the borings for the McKinley Bridge I discovered there was from 10 to 20 ft. of silt along that bank of the river. It would have been much better to have founded this abutment on bed rock, but if piles were to be used, some of them should have been battered, and all of them should have reached bed rock. To make matters worse the filling which was placed back of this abutment consisted of ashes, manure, and other light refuse.

I left Peoria in July, 1907, but passed through the city on other business just a year later. On the afternoon of July 25, 1908, I walked down to the bridge and was surprised to find all of the arches badly cracked. The sketches (Fig. 7) showing the location and size of the cracks were made on that afternoon. It was noticeable that the south abutment had settled and had also been thrust backward. I made an estimate at the time (without instruments) of the apparent movement in each direction, but cannot recall the figures at present.

Yours very truly,
J. W. Woermann,
428 Custom House, St. Louis, Mo.

Mr. Edwin Thacher, of the Concrete-Steel Engineering Co. who made the design for the bridge, has issued the following statement:

Statement of Mr. Edwin Thacher,* M. Am. Soc. C. E.

Starting at the north end, the Peoria City Bridge consisted of retaining walls, 202 ft. long, with an earth fill between them; one 110-ft. arch, one 135-ft. lift span, and four 125-ft. arches, and the total length of bridge and approach over all was 1,119 ft.

The only eye witnesses of the fall of the bridge on May 1, were a bridge superintendent and a night-watchman, who stood near the bridge house at the south end of the lift span, and within a few feet of the first span to fall. One of these men states that this span appeared to rise in the air, break and then fall into the river. This was followed in rapid succession by the fall of the second and third spans and piers 3 and 4.

The failure was due solely to insecure foundations, the foundation of pier No. 3 next to the lift pier being the first to give way. The three

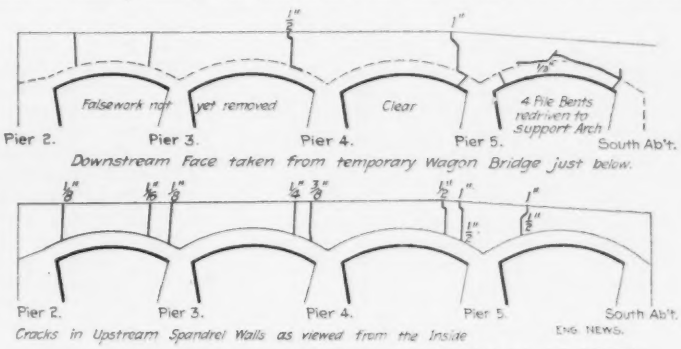


FIG. 7. DIAGRAM SHOWING CRACKS IN ARCHES OF PEORIA BRIDGE, JULY 25, 1908.

125-ft. arches that fell were without crack or blemish that anyone had ever been able to discover.

This bridge was designed by the Concrete-Steel Engineering Co. of New York. The profile and borings on which the design was based, were furnished by the city of Peoria, and the bridge was constructed by the Marsh Bridge Co. of Des Moines, Ia. The Concrete-Steel Engineering Co. has an agreement with the city of Peoria to furnish plans and specifications, and to act as Consulting Engineers during the construction of the bridge when necessary and called upon by the engineer in charge of the work. The city of Peoria had entire charge of the work of construction, furnishing its own engineers and inspectors.

The specifications provide that the foundations

*Concrete-Steel Engineering Co., New York City.

of piers Nos. 1 and 2, carrying the Scherzer Rolling Lift, shall be carried down to solid rock, and that all other foundations shall be on piles driven to rock, the piles being not less than 8 ins. in diameter at small end, and from 12 ins. to 16 ins. in diameter at the large end; that all pile foundations shall be inclosed by permanent watertight tongue-and-groove sheet piling or Wakefield piling, sawed off at least 1 ft. below low water. The plans show that the foundation piles for the piers, and the four rows nearest front of each abutment, should be driven vertically, and that the five rows of piles at rear of abutments should be driven on a batter of one to four, or on a batter of 5 ft. in length of 20 ft.

The specifications provide that the earth fill over the arches and abutments shall be put on before the centers are struck.

The foundations for piers 3, 4 and 5, between lift span and south abutment, were carried for 7 to 8 ft. below bed of river. The piles under piers 3 and 4 were about 12 ft. long, and under pier 5 about 14 ft. long, and were supposed to be driven to solid rock.

The bed of river at bridge site has considerable bearing power, when undisturbed, but is readily scoured and liquefied by running water. The piers of the old free bridge, alongside the new bridge, rested on a single course of hewn timbers, laid side by side, and had no support except the bed of river. They supported spans of from 129 ft. to 145 ft. safely for 30 years or more. A calculation shows that the pressure on the foundations must have been not less than two tons per sq. ft. The elevation of the timber base of these old piers was about 5 ft. higher than the base of the new bridge piers.

The object of the designers, in specifying that all pile foundation should be permanently protected by watertight sheet piling, was to protect them from scour, so as to benefit, as far as possible, from the earth foundations and the frictional resistance of the piles. None of the foundations were protected by sheet piling, watertight or otherwise, but were exposed to the full action of the current. In consequence of this the designers, in a report to the Mayor, dated June 16, 1908, and also verbally and by letter several times since that date, urged that all pile foundations should be promptly protected by heavy and careful riprapping, but no riprapping has been done.

On June 6, 1908, soundings were taken during a falling stage of the water. At pier No. 3 the scour had extended 3.8 ft. below the base of pier, or say 11 ft. below the original bed of river. At pier No. 4 the scour had reached a depth of 2.0 ft. above base of pier, and at pier 5 a depth of 2.4 ft. below the base of pier. At high stages of water the scour was undoubtedly very much greater, removing the greater part of the material under the piers, and leaving the piles practically without lateral support.

Great concern regarding this bridge has been felt by the designers since May 23, 1908, about a month after the spans were swung clear of the centerings, when a telegram was received from Peoria, indicating trouble at the south abutment. On May 25, 1908, more definite information was received stating that the south abutment had settled in front and moved outwards, and that the south arch had deflected greatly. The designers wired, requesting that all spans be wedged up at once; this was done about three months later. On the morning of May 28, a member of the designing firm reached Peoria and started an investigation extending over a period of four weeks. Levels and check levels were promptly taken over the entire bridge, between pier No. 2 and south abutment. The levels were taken on top of the spandrel walls on each side of bridge, over each springing line and at 25-ft. intervals over the arches. The results of these levels were unexpected and astounding, as they gave pier 2 from 4½ to 5¼ ins. below grade; pier 3 from 4¾ to 7¼ ins. below grade; pier 4 from 4½ to 5½ ins. below grade; pier 5 from 3⅛ to 3⅜ ins. below grade, and the front of south abutment from 5½ to 5¾ ins. below grade. It was known that there could have been no settlement at pier No. 2, as the foundation was carried down to solid rock. The engineering department at Peoria believed there had been no settlement at any of the piers, and there was considerable ground for such a belief; for it was argued that if a mistake in levels of 5¼ ins. could be made at one point, even greater mistakes could have been made at other points.

Calculation showed that the weight on the piles at that time, if uniformly distributed, could not have exceeded 21.4 tons at pier No. 3; 20.3 tons at pier No. 4, or 18.3 tons at pier No. 5. The piles were supposed to have been driven to rock; they were from 12 ft. to 14 ft. long, and the ultimate strength of a specification pile of that length could not be much less than 200 tons.

Unfortunately no levels had ever been taken over the bridge, either before or after the centerings were lowered, so there was nothing to check against, and it could not be known to a certainty whether any settlement had taken place at the piers or not.

In consideration of the above facts the designers were in time inclined to accept the view of the local engineers that the piers had not settled, though all apprehension on the subject had by no means been removed.

It was evident that the south abutment had settled several inches in front and moved outward several inches, and steps had to be taken to strengthen it. A plan was submitted by the Concrete-Steel Engineering Co. and accepted by the city of Peoria, and the contract was let to the Marsh Bridge Co. The plan consisted of underpinning the abutment by heavy walls of concrete, carried down to solid rock. The walls were 44 ft. long, 12 ft. wide at the base and the height from bottom of abutment to rock was from 17 to 20 ft., and from low water to rock about 26 ft. The work was difficult and hazardous, but it had been completed successfully on the west side and was within about a week from completion on the east side when work was stopped by high water. Great credit is due to Superintendent Mullen for his constant care and watchfulness during the prosecution of the repair work, under adverse conditions and with very imperfect machinery and appliances. Breakdowns of motors or pumps were of almost daily occurrence. With a good plant, and proper financial support, the work would have been completed long before high water interfered with it. The method adopted for strengthening this abutment could hardly fail to be effective in preventing any further movement downwards or outwards.

Owing to the long delay in wedging up the arches, and the partial undermining of the abutment during the work of strengthening a further movement downwards and outwards was observed, amounting altogether probably to not less than 12 ins. outwards and 6 ins. downwards.

In order to arrive at the most probable cause of the movement of the south abutment the following facts are given.

The permanent sheet piling specified for protecting this foundation was not put in.

The scour at this abutment was considerable, extending 3 ft. or more below the bottom of the abutment in the rear before the fill was put in. This was filled in with manure and other light material for a depth of several feet, and then with rock and earth up to grade.

No record was kept of the piles driven in any foundation, as to weight of hammer, number of blows, size and batter of piles, penetration or anything else, except that the piles appeared to drive quite hard. The actual condition of the piles and the strata through which they were driven, are quite fully described in the statement made by Mr. Mullen, Superintendent in charge of strengthening the abutment, and south arch, to Mr. Edwin Thacher on May 3, 1909, which is as follows:

DOWN-STREAM SIDE EXCAVATION FOR SUPPORTING WALL.

Went through mud and clay mixed about 7 ft., next about 10 ft. of sand and clay mixed, then about 6 or 7 ft. of silt and clay, then 2 to 4 ft. of clam shells, then about 10 ins. of sand and clay, then 1½ to 2½ ins. of soap stone, then 9 or 10 ins. of sand and clay mixed, then 18 ins. of rotten slate, then solid slate. The excavation started about 6 or 7 ft. above base of abutment.

Drove four new piles, undermined nearly all the piles on the down stream side, none of the piles went to solid slate, most of the piles ended in rotten slate. Most of the piles in the front of abutment were broken.

The concrete wall extends under the abutment 5 ft. in front and 6 ft. in rear, the excavation for which uncovered 17 piles. Many piles were exposed back of the excavation.

The four front rows of piles exposed were inclined about 1 ft. backwards. The five rear rows of piles were standing about vertical instead of being inclined on an angle of 1 to 4.

UP-STREAM SIDE EXCAVATION FOR SUPPORTING WALL.

A wall was carried to solid slate for a length of 15½ ft., about 2 ft. being in front of the abutment and 13½ ft. under the abutment. The excavation for this side was about the same as for the down stream side until the layer of shells was reached. Then came a thickness of about 4 ft. of shells, then about 4 ins. of soapstone, then about 6 ins. of sand and clay, then about 12 ins. of rotten slate, then about 12 ins. of shells, slate and nigger heads, then came solid slate.

Most of the piles on this side were broken. The piles in this part of the abutment were inclined about 1 ft. backwards, except one pile which was inclined about 5 ft. forwards. Four new piles were driven, and nearly all of the old piles were undermined in the excavation, one being removed entirely. None of the piles went to solid slate, and it was found that one pile that should have been driven was never driven. At the rear of this abutment excavation had been carried down 13 ft. and ended in a layer of quicksand, when high water stopped the work. This excavation was stopped about 9½ ft. above solid slate; so that the condition of bottom or location of rock for about 20 ft. from the back of the front wall to the rear of the abutment had not been uncovered and is unknown; but it is supposed that the conditions are about the same as were found to exist in excavating for the front wall. The piles in the rear of the abutment were found in good condition except they were about vertical instead of being battered at 1 to 4. The wall extends under the abutment about 4½ ft. in front, and 6 ft. in rear, the excavation for which uncovered 17 piles, 6 of which are bedded in the concrete wall.

About one-third of the total number of piles in the abutment were uncovered, and it is probable that the condition of the piles not uncovered is about the same as those uncovered, as to penetration, inclination and condition of piles.

It is believed by the designers that if this foundation had been protected from scour by permanent sheet piling, as specified, and all piles had been driven to rock, as specified, and at the inclination specified, that there could have been no movement of the abutment downwards or outwards.

Mr. Charles Van Lanningham, who was engaged in excavating for pier No. 2, 540 ft. north of south abutment, stated to the writer that the piles went through clay and mud, then shells, then soapstone, then a few inches of clay to solid slate, on which the foundation was placed, and that the excavation at pier No. 1 was about the same. It is clear from the statements of Mr. Mullen and Mr. Van Lanningham that the material in bed of river above solid rock was variable, uncertain and treacherous, all along the line, and that shells were liable to be found at any point. It is probable that the movement of south abutment affected to a greater or less extent all spans and piers between it and pier No. 2. It is also probable that few, if any, of the piles under the piers went to solid rock, and that very unequal pressure was borne by the piles, by reason of the variable value of the strata in which they terminated.

As previously stated the foundations had been deeply undermined by scour; the stability, due to the earth foundation, had been destroyed; the frictional resistance of the piles had also been destroyed, and the piers were left standing on stilts. Various things may have happened, some of the piles may have broken through thin strata of rock or shells, some of the piles may have been crushed by reason of the unequal distribution of pressure, or the piers may have been pushed over bodily by the force of the current by reason of insufficient lateral support.

The visible parts of pier No. 4 appear to be about 12 ft. downstream and 20 ft. north of the

original position, and pier No. 3 is canted downstream.

Whatever may have been the immediate cause of the collapse it is certain that the weight on the foundation piles at the time was not very great. All spans were supported on centerings and supposed to be well wedged up, and these centerings were amply sufficient to support the weight of the arches. Most of the earth fill between the spandrel walls was in place. But assuming that the centerings took no load whatever, the weight on the foundation piles could not have exceeded 29.8 tons at pier No. 3, 28.8 tons at pier No. 4 and 26.8 tons at pier No. 5, a small fraction of the strength of a specification pile driven to rock.

We firmly believe that if the pile foundations had been protected by permanent cofferdams as specified, preventing scour, preserving the bearing power of the soil on which the piers rest and the frictional resistance of the piles, that these piers would have stood regardless of the treacherous nature of the river bottom, or whether all piles reached solid rock or not, although it was specified that all piles should be driven to rock.

[Signed]
CONCRETE STEEL ENGINEERING CO.,
By Edwin Thacher.

AN EXPLOSION OF DYNAMITE demolished a steam shovel on the Northern Pacific Ry., 30 miles east of Missoula, Mont., May 4. The craneman of the steam shovel and two helpers were killed and three others were injured.

A POWDER MILL EXPLOSION at the Laflin-Rand mills, near Columbus, Kan., May 10, killed four men employed in the mixing room. Reports state that this is the fourth time the mixing room of this mill has been wrecked by an explosion and that the three previous explosions killed three, two and five men, respectively.

THE PACIFIC ENTRANCE TO THE PANAMA CANAL, heretofore known as La Boca, is, by order of the President, hereafter to be known as Balboa, in honor of the discoverer of the Pacific Ocean.

A PHENOMENAL TUNNELING RECORD is reported to have been made in the Loetschberg Tunnel during March, in the north heading, which until February, 1909, remained idle since the break-in 8,774 ft. from the portal last July. In February a new heading was started, for a line diverging from the north tunnel at 3,946 ft. from the portal. The new tunnel was mere widening work for 541 ft., heading work being started at 4,487 ft. During February the new face was advanced 144 ft. During March, 1909, the "Schweizerische Bauzeitung" of April 17 gives the advance of this heading as no less than 242 meters, or 794 ft.! What this means may be judged from the fact that the best previous heading advance in one month, made in one of the Simplon tunnel headings, was about 685 ft. Thus the record is suddenly increased by over 100 ft. Four drills were used. The heading lay in limestone ("Neokomkalk"). During the same month the south heading, working with four drills in metamorphosed limestone and shale rock, advanced only half as much, or 394 ft.

RAILWAY TRAIN ACCIDENTS in the fourth quarter of 1908 caused the death of 21 passengers and injured 1,390, according to Bulletin 30 of the Interstate Commerce Commission. In the same period 148 employees were killed and 1,519 injured. A train caught in a forest fire at Metz, Mich., on Oct. 15, 1908, caused the death of 13 passengers and 2 trainmen and injured an equal number; but this is not included in the above figures, though the Commission includes it and classifies it as a derailment. The list of train accidents for the quarter comprises 1,373 collisions (151 butting, 303 rear, 919 others), and 1,311 derailments (629 were due to defects of equipment, 242 to defects of roadway). Of the 26 most serious collisions, no less than 20 are chargeable directly to the train-order system or to lack of fixed signals.

A TWO-MILE TUNNEL IN THE ALPS was holed through on April 2, 1909. It lies between Brunnadern and Lichtensteig, on the new Bodensee-Toggenburg connecting railway in northern Switzerland, and is called the "Wasserfluh" tunnel. Its length between portals is 11,067 ft. The survey juncture showed a divergence in alinement of 2 ins., in elevation ½-in., and in distance 11 ins. (excess). The tunnel is on a 1.04% gradient, rising toward the east (Brunnadern). It is single-track, 17 ft. wide by 18 ft. 4 ins. high in the clear, and is lined with 16 ins. of masonry. The heading work was done with 3½ × 9-in. air rock drills, but for the full-section excavation pneumatic hammer drills were used. (Schweizerische Bauzeitung, April 10, 1909.)

PANAMA CANAL EXCAVATION during April totaled 3,454,649 cu. yds., for the 25 working days, a daily average of 138,186 cu. yds. This daily record has been passed in only one other month, March, 1909, when the daily average for 27 days was 150,468. The record for the past two months is as follows:

	April.	March.
Steam Shovels:		
Atlantic division	151,711	155,334
Central division	1,782,766	2,054,088
Pacific division	203,384	143,481
Dredging:		
Atlantic division	520,990	603,046
Pacific division	795,798	924,388
Accessory work outside canal excavation proper:		
By steam shovel	110,940*	182,295
	3,454,649	4,062,632

*Not counted in the total addition; included in figures above.

It should be remarked that in the above tabulation the 116,421 cu. yds. noted in our last month's tabulation (Eng. News, April 15, 1909, p. 421) as "Accessory works outside of Canal Prism," have been distributed among the various divisions in the "steam shovels" items, so that the March items here given do not agree with the items for that month in the previous note, although the totals are the same; also that the 110,940 cu. yds. accessory excavation in April is distributed among the divisions and so is not counted in the addition.

The rainfall during April was 4.36 ins., as against 1.10 ins. in March.

THE COMPETITION FOR A WET-GRAINS CONveyor of the Anheuser-Busch Brewing Association, St. Louis, Mo., noted in our issue of Jan. 28, 1909, was won by Mr. Walter Samans, of Greenville, Pa. The prize offered was $250.

A SLIGHT IMPROVEMENT IN THE FREIGHT-CAR situation is reported for the last record date, April 25, 1909. The number of idle cars decreased by 14,335, bringing the total surplus down to 282,328 cars. Practically the whole reduction is in coal and gondola cars, while box cars remain about stationary. The largest decreases are in the North Atlantic and Northwestern groups of railways.

FREIGHT CARRYING ON ELECTRIC RAILWAYS in Pennsylvania is furthered by two new laws, just signed by Governor Stuart. One of the laws authorizes electric lines to carry freight of all kinds (instead of only light freight, as hitherto permitted), provided the consent of the local authorities is obtained. The other law authorizes steam and electric railways to connect their tracks and interchange cars, with the consent of the local authorities; but no steam locomotives may be run over the electric lines. Both laws provide that the local permits are revocable after ten years. These laws are claimed to apply to the Philadelphia subway as well as to surface lines.

AN 85-CENT GAS RATE for San Francisco has been fixed by the Board of Supervisors for the coming fiscal year.

A METROPOLITAN WATER DISTRICT for San Francisco and vicinity is authorized by a bill which has passed the State Legislature and been approved by the Governor. Under the bill, as we understand it, San Francisco and a number of cities across the bay, including Oakland, Berkeley and Alameda, and in addition the peninsular cities in San Mateo County, will be permitted to join forces in providing a publicly-owned water-supply. It is stated that the Governor of California refused to sign the bill which was designed to facilitate the acquisition of the property of the Spring Valley Water Co. by San Francisco. The bill was an amendment to the condemnation-proceedings law, and declared the property used by cities for water-works purposes was devoted to a higher use than when similarly used by a private company. The San Francisco Board of Supervisors has fixed the water rates for the ensuing year on the same basis as for the past year, despite the efforts of the Spring Valley Water Co. to secure higher rates on the ground that otherwise much-needed extensions will be impossible. As many of our readers know, the water rates of San Francisco, as established from year to year by the Board of Supervisors, have been a subject of litigation for many years past, and the controversy is not yet settled.

A DAM ACROSS THE MISSISSIPPI between St. Paul and Minneapolis is to be made the subject of a public hearing at the Commercial Club, St. Paul, on June 9, 1909. In the River and Harbor Act, passed by the federal Congress, March 3, 1909, the Secretary of War was authorized to investigate the hydraulic situation at this place "with a view to modification of project to provide for increased depth and utilizing the surplus water for development of power." Accordingly a board composed of engineer officers, Maj. Charles S. Riche, Maj. Francis R. Shunk and Maj. Charles S. Bromwell, has been appointed to report on the matter. This board has issued the following statement:

The board is governed in its investigations by the following instructions received from the War Department, Office of the Chief of Engineers:

"The provision for water-power investigations was inserted to cover those cases where an improvement for navigation alone would prevent the proper development of valuable water powers which might readily be provided for at little or no sacrifice of the interests of navigation, and where a coordinate development for both navigation and power will not result in an increase of cost to the United States, but may lead to a substantial reduction, due to contributions from water-power interests."

Having made full investigations, the board has reached the conclusion that no substantial modification of the present project is necessary in order to provide such depths as are needed for purposes of navigation, but that the present system of two dams must be abandoned and a single high dam, at the site of No. 1, substituted, in order to provide for the development of power. The board further finds that the construction of such high dam is perfectly feasible, the foundation being good and the site otherwise suitable. But, such high dam not being required for navigation purposes, the board cannot recommend that it be built at the sole expense of the United States.

The board, however, recognizes that the development of waterpower made possible by the construction of a high dam would be of great benefit to the community, and that such development of power would involve no sacrifice of the interests of navigation. The case is therefore one of those contemplated in the instructions given above.

A dam at the site of No. 1 could be given a lift of 30 ft., or possibly more, without interfering with the power plants at Minneapolis. Records of flow and other information may be obtained at the U. S. Engineer Office, St. Paul, Minn.

It is probable that the Federal Government will stipulate that a certain amount of power, not probably to exceed 1,000 HP., be furnished free of cost to the United States.

Excluding the cost of flowage rights, the high dam will cost $170,000 more than the low dam authorized. It is estimated that flowage rights can be acquired for $80,000.

These additional sums at least must be furnished by parties other than the United States in order that the high dam may be built. It is, of course, understood that the estimated cost of the dam does not include a power-house or installation of plant; which must be provided for by the party or parties who may cooperate with the United States.

The board invites full discussion of the matter, and will be glad to receive proposals, arrange such terms and conditions as it can recommend, and give such information as may be possible.

It must be understood that the powers of the board, and of the War Department, are limited to recommendation. Congress alone can take enabling action.

REINFORCED-CONCRETE HOUSES FOR EARTHQUAKE COUNTRIES.—The catastrophe in Southern Italy has revived the interest in the kind of construction which may logically be adopted to reduce the disastrous consequences of earthquakes to a minimum. The resistance of the buildings in the village of Faveliani, in Calabria, which was entirely rebuilt in reinforced-concrete after the earthquake of 1905, and the stability of the four or five houses of the same construction which remained intact in the middle of the ruins of Messina, serve as arguments for those specialists who are advocating this mode of construction.

In the Italian journal "Cemento," Jan. 15, 1909, Mr. A. Danusso discusses some of the characteristics of reinforced-concrete buildings which, if they are constructed with care, will either perfectly resist abnormal forces or will not fall suddenly. The collapse, if it should be produced, will be preceded by very evident defections and cracks, and the slow disintegration will give the residents ample time to leave the building. From the various forces which the different parts of the building must undergo under earthquake vibrations, the author deduces certain principles of construction. He excludes excavations which would cause unstable equilibrium of the building, and recommends that no more than two stories be built, or if more are required the upper stories should be built of the lightest material. The skeleton in reinforced concrete should rest on a platform which will distribute the pressure over the earth. It is indispensable that the partitions be tied together at their corners.

Mr. C. Pesenti studies the question under a somewhat different aspect in "Cemento," Feb. 15. After a comparison of the different materials, not only from the point of view of stability, but from the conditions of habitability, he gives the preference to reinforced concrete. He says the construction should form an elastic monolith placed on a platform of which it is independent. The surfaces of contact between the building and the platform should be as small as possible so as to permit displacements, and also to reduce the vibration. The type of roof and of platform foundation which he shows seem to satisfy these desiderata. Underneath the walls and above the footings he proposes to place two plates of galvanized iron, between which is interposed a layer of lead.

In "Cemento," Feb. 28, Mr. L. Novelli studies the effects produced by vertical and horizontal vibration on the walls of a building. He concludes that ordinary masonry is not able to resist such violent movement, and, as wood and iron are inconvenient materials for building construction, he recommends the employment of reinforced concrete.—Le Genie Civil, April 17, 1909.

OF WEST POINT FIRST-HONOR MEN, all those of the last 45 graduating classes (1864-1908) are now living, and about three-fourths of these men are still on duty in the Engineer Corps, U. S. A. Eight have retired, two have resigned and one, Oberlin M. Carter, class of 1880, was dismissed from the service. Of the 34 remaining in active service, all but two are in the Engineer Corps.

A RECENT GRADE-CROSSING DECISION in favor of the city of Minneapolis by the U. S. Supreme Court establishes more firmly the rule that the cost of grade-crossing abolition may be charged wholly to the railroad company, and that the action of the city in ordering a crossing to be made safe is a proper exercise of the police power. This decision was based on a prior decision (Feb. 24, 1908) in a Duluth grade-crossing case. The latter, because of a particular complication, is of special interest. Its history was briefly as follows: The predecessors of the Northern Pacific Ry. Co., under a state charter, laid their first track across what is now Lake Ave., Duluth, in 1869. Lake Ave. was graded and improved in 1871. Twenty years later the increase of traffic, of tracks, etc., made the crossing dangerous, in the city's opinion, and the city made plans for a viaduct and demanded that the railway build it. The company denied any obligation, and finally managed to make a compromise contract with the city to pay $50,000 towards the cost, the city to maintain that part of the viaduct within the right-of-way for 15 years. In 1903 the viaduct had got into a dangerous condition; the city made plans for its improvement, and the city council passed a resolution demanding of the railway company that it repair the structure accordingly. Upon the company's refusal, the city started an action of mandamus, and won out in this, both in the State Supreme Court and in the U. S. Supreme Court. The U. S. Supreme Court obtained jurisdiction through the railway company's claim that its rights, as established by the 1891 contract with the city, were violated. The decision of the Supreme Court, which is reported in 208 U. S., page 583, says in effect that to require a crossing to be made safe is a proper exercise of the police power; that the right to exercise the police power is a continuing one; that it cannot be contracted away; and that the contract of 1891 was void and beyond the power of the city to make. This is held even in the face of the railway company's allegation, that, since in 1891 the legal rights of the two parties had not been very fully established by court decisions and were surrounded by much doubt, the contract was a legitimate compromise between the parties, which, therefore, ought to be carried out. The court replies that

> the exercise of the police power cannot be limited by contract for reasons of public policy, nor can it be destroyed by compromise, and it is immaterial upon what consideration the contract rests.

A further important feature of the Duluth case is that Lake Ave. was laid out after the railway first crossed the location, and that the decision includes this factor. The Supreme Court says that the railway company's charter and common-law obligations to maintain substantially unimpaired the traffic facilities of streets and waterways which it crosses apply very obviously to streets which may be laid out in the future as well as to streets in existence at the time the railway was built.

Personals.

Mr. Clay Belsley has been appointed City Engineer of Peoria, Ill.

Mr. George C. Sellon has resigned his position as State Architect of California.

Mr. Charles Worthington Comstock, M. Am. Soc. C. E., has been appointed State Engineer of Colorado.

Mr. J. H. Davis, Assistant Electrical Engineer of the Baltimore & Ohio R. R., has become Electrical Engineer, succeeding L. T. Gibbs, deceased.

Mr. T. N. Jacob, of East St. Louis, Ill., has been appointed Chief Engineer of the East Side Levee and Sanitary District of St. Louis, Mo.

Rear-Admiral Wm. P. Potter, U. S. N., will, on July 1, succeed Rear-Admiral John E. Pillsbury, retired, as Chief of the Bureau of Navigation.

Mr. J. M. Schoonmaker, Vice-President of the Pittsburg & Lake Erie R. R., has become President of the Monongahela R. R., succeeding Mr. Joseph Wood.

Mr. Bernard Elshoff, Assoc. Am. Inst. E. E., has withdrawn from his position as Superintendent of the Electrical Department of the Allis-Chalmers Co., in Milwaukee, Wis.

Mr. W. F. King, who has been for several years Chief Astronomer of the Dominion of Canada, has been appointed Superintendent of the recently authorized Geodetic Survey of Canada.

Mr. Jerome Cochrane, Professor of Civil Engineering at the John B. Stetson University, De Land, Fla., has submitted his resignation, to take effect at the end of the present school year.

Mr. Wm. T. McCormick, formerly Superintendent of the Tuscaloosa (Ala.) Water-Works, has become Secretary and Chief Engineer of the Greer Filter Manufacturing Co., Inc., of Woodbine, N. J.

Mr. Charles B. Richards, M. Am. Soc. M. E., Professor of Mechanical Engineering for the past 25 years at the Sheffield Scientific School of Yale University, is reported to have signified his intention of resigning that position, effective next June.

Mr. Dwight T. Randall, M. Am. Soc. M. E., recently in charge of fuel tests for the Technologic Branch, U. S. Geological Survey, at Pittsburg, Pa., has become associated with the Arthur D. Little laboratory of engineering chemistry of Boston, in charge of the fuel testing department.

Mr. Henry Gerharz, Mr. E. W. Colton, Mr. C. E. Shipman and Mr. E. M. Sneckenberger have organized the Henry Gerharz Engineering Co. in Billings, Mont. The new firm will take over the private practice of Henry Gerharz, in whose office the other three members have been employed as assistants.

Mr. Jacob H. Prost has been appointed City Forester of Chicago, Ill. In the examination recently held for this position, he received the mark of 92.5%, six points higher than that of his nearest competitor. Mr. Prost received the degree of B. S. from the Michigan Agricultural College with the class of 1904, and has been employed for the past three years on the West Chicago park board staff.

Mr. Frank L. Getman, Assoc. M. Am. Soc. C. E., and Mr. Thomas M. Keene, of Havana, Cuba, have entered into partnership under the firm name of T. M. Keene & Co., with headquarters at Havana. The new firm will deal in construction supplies and engage in general engineering and contracting. Both Mr. Getman and Mr. Keene were connected with the office of the City Engineer of Havana during the first American occupation.

In connection with the separation of the Utah Lines of the Denver & Rio Grande R. R. into two divisions, a number of changes have been announced as follows: Mr. A. B. Apperson, formerly Assistant Superintendent at Salt Lake City, has been made Superintendent of the Salt Lake division, with headquarters at Salt Lake City. Mr. O. J. Ogg, formerly Assistant Superintendent at Helper, has been made Superintendent of the Green River division, with headquarters at Helper. Mr. F. O. Hyamond, Mr. C. A. Roberts and Mr. C. W. King, formerly trainmasters at Bingham Junction, Tucker and Salt Lake City, respectively, have become assistant superintendents.

Obituary.

Alexander Miller, M. Am. Soc. M. E., died May 6 at his home in Jersey City. He was born at Aberdeen, Scotland, in 1844 and came to this country when a boy. His father became Superintendent of the Delamater Iron Works and he himself was employed for some time by that firm as a draftsman. About 20 years ago, Mr. Miller became the junior partner in the firm of Brown & Miller, proprietors of the Vulcan Iron Works in Jersey City. The firm name was changed, after the death of Mr. Brown, to Alexander Miller & Bros., and Mr. Miller was at its head up to the time of his death.

Ralph Scott, Assoc. Am. Inst. E. E., died April 25 at Newark, N. J., at the age of 26 years. His death was due to appendicitis. Mr. Scott was born in Bradford, England, but came to America when a child. He became interested at an early age in electrical work and was active in that field as an inventor besides being the author of several papers on that subject, which were published in technical periodicals, and of a book on automatic block signals. He was the inventor of the Scott flaming arc lamp and is said to have held 40 patents on electrical devices. Mr. Scott was admitted to the American Institute of Electrical Engineers about one month before he died. At the time of his death he was joint proprietor of the Scott Electrical Co., of Newark.

Charles Harris, Superintendent of Streets of Boston, Mass., from 1864 to '83, died May 6 at his home in Cambridge, Mass. He was born at Cambridge in 1832 and was the son of Thaddeus W. Harris, who served as librarian of Harvard University for 25 years. Charles Harris was educated in the schools of Cambridge and afterward graduated at the Lawrence Scientific School. After graduating, he left Massachusetts for the Middle West, where he was employed for several years on the engineering staff of the Ohio & Mississippi Ry. Returning to Boston in 1854, he became Assistant City Engineer and continued in this position until, in 1864, he was made Superintendent of Streets. West Roxbury, Brighton and Charlestown were annexed to the city during Mr. Harris' term of office and he had charge of the filling-in of the Church St. district and the leveling of old Fort Hill. Upon leaving the superintendency in 1883, he became agent for an asphalt paving company, which did considerable work in Boston. Mr. Harris had served for several years on the Cambridge Board of Health.

Engineering Societies.

COMING MEETINGS.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 18-20. Annual meeting at Cincinnati, Ohio. Secy., Richard Moldenke, Watchung, N. J.

AMERICAN RAILWAY ASSOCIATION.
May 19. Annual meeting at New York City. Secy., W. F. Allen, 24 Park Place, New York City.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 25-27. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 1-4. Annual convention at Atlantic City, N. J. Secy., W. W. Freeman, 29 West 39th St., New York City.

AMERICAN WATER-WORKS ASSOCIATION.
June 8-12. Annual convention at Milwaukee, Wis. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 16-18. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 21-23. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
June 21-23. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, C. & E. I. R. R., 327 La Salle Station, Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 23-25. Annual meeting at Detroit, Mich. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-25. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
July 6-9. Annual convention at Bretton Woods, N. H. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 13-15. Annual convention at Toledo, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 15-16. Summer meeting at Indianapolis, Ind. Secy., W. M. Mackay, P. O. Box 1818, New York City.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held at the Society's rooms in Chicago on May 5, resolutions were adopted in favor of appointing engineer members upon the proposed commission to revise and codify the building laws of the state of Illinois. A bill providing for the appointment of such a commission is now before the state Legislature. In this bill special stress is laid upon the engineering features (structural and sanitary) of buildings, and the mechanical and electrical features of their equipment. The Society (in its resolutions) expressed the opinion that the engineering profession should be more fully represented upon the commission in order to obtain the desired results.

It was recommended that the commission should include one member from each of the following societies: The Western Society of Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. These four members to be residents of the state of Illinois. The resolutions will be sent to the Governor of Illinois and to the officers and members of the state legislature, as well as to the three national engineering societies.

An interesting paper on "The Engineering Experimental Station at the University of Illinois, and Its Relation to Illinois Industries," was read by Prof. L. P. Breckenridge, who has been the Director of the station (as well as Professor of Mechanical Engineering at the University) since the station was established in 1903. The work and purpose were described, and much interesting information was given as to the industrial importance of Illinois and the relations of the experiment station to the industrial development. Its establishment followed the precedent of the highly successful agricultural experiment station instituted at this and other universities by the U. S. Government, but Illinois was the first state to institute an engineering experiment station, in conjunction with its state university. We have at different times published considerable information as to the tests and investigations carried on.

The meeting ended with an ovation to Prof. Breckenridge, who has resigned his position at the University of Illinois and has accepted a similar position at the Sheffield Scientific School of Yale University at New Haven, Conn. His change is of special interest in that it is expected that an Engineering Experiment Station will be established at Yale.